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THE FUTURE OF AVIATION

A COMPILATION OF PAPERS

PREPARED BY THE

SUBCOMMITTEE ON

AVIATION AND TRANSPORTATION R. & D.

OF THE

COMMITTEE ON

SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

NINETY-FOURTH CONGRESS

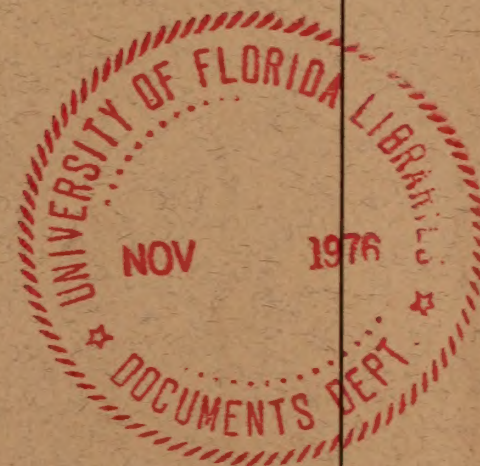
SECOND SESSION

Serial EE

VOLUME II



JULY 1976



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CONTENTS

	Page
Foreword.....	v
STATEMENTS	
Prof. Neil A. Armstrong, professor of aerospace engineering, University of Cincinnati, also advisory member of Kenton County Airport Board, Cincinnati.....	2
Prof. Holt Ashley, professor of aeronautics and astronautics and mechanical engineering, Stanford University.....	9
Harold S. Becker, vice president and treasurer, The Futures Group.....	12
John G. Borger, vice president and chief engineer, Pan American World Airways, Inc.....	46
John C. Brizendine, president, Douglas Aircraft Co. Division, McDonnell Douglas Corp.....	58
Dr. Robert H. Cannon, Jr., chairman, Division of Engineering and Applied Science, California Institute of Technology.....	74
Richard E. Cohen, Bureau of International Commerce, U.S. Department of Commerce.....	81
Harry E. Colwell III, vice president, Chase Manhattan Bank, N.A. and division executive of its aerospace division.....	113
Andrew de Voursney, group vice president—finance and planning, United Airlines.....	118
George C. Eads, executive director, National Commission on Supplies and Shortages.....	129
Glen A. Gilbert, Glen A. Gilbert & Associates, aviation consultants.....	145
Prof. Paul Gray, chairman, department of quantitative business analysis, University of Southern California.....	170
J. C. Green, manager of operations analysis, Sikorsky Aircraft.....	186
Malcolm Harned, president, Cessna Aircraft Co.....	191
Willis M. Hawkins, senior adviser, Lockheed Aircraft Corp.....	199
Dr. Klaus P. Heiss, president, ECON, Inc.....	204
Prof. Robert Horonjeff, professor of transportation engineering, University of California, Berkeley.....	283
David R. Israel, Technical Assistant to the Administrator, Energy Research and Development Administration.....	296
Franklin W. Kolk, vice president—technological development, American Airlines.....	313
John F. Leyden, president, Professional Air Traffic Controllers Organization.....	321
Hans Mark, Director, Ames Research Center, National Aeronautics and Space Administration.....	328
Dr. Richard R. Nelson, professor of economics, Yale University Institute for Social and Policy Studies.....	330
William H. Ottley, executive director, National Pilots Association.....	353
Frank N. Piasecki, Piasecki Aircraft Corp.....	358
Paul H. Poberezny, president, Experimental Aircraft Association.....	383
Simon Ramo, vice chairman of the board and chairman of the executive committee, TRW.....	387
Robert A. Richardson, executive director, Helicopter Association of America.....	392
John E. Robson, Chairman of the Civil Aeronautics Board.....	401

IV

R. W. Rummel, vice president, technical development, Trans World Airlines-----	Page 405
Dr. Abe Silverstein, retired director, Lewis Research Center, National Aeronautics and Space Administration-----	409
Ronald Smelt, vice president and chief scientist, Lockheed Aircraft Corp-----	412
Floyd E. Smith, international president, International Association of Machinists and Aerospace Workers-----	424
Dr. H. Guyford Stever, Director, National Science Foundation-----	428
T. R. Stuelpnagel, vice president and general manager, Hughes Helicopters-----	457
Charles M. Walker, Assistant Secretary of the Treasury-----	497
Henry C. Wallich, Member, Board of Governors of the Federal Reserve System-----	516
John H. Winant, president, National Business Aircraft Association-----	538

FOREWORD

From the first days of powered flight, the United States has played a leading role in the development of aviation. Through the steady application of newer technology, we have continually developed faster, safer, larger, and more reliable aircraft.

In recent years, the United States has been absolutely preeminent in the world marketplace. Today, 85 percent of the commercial aircraft flying in the free world are of U.S. manufacture. The economic benefits of this have been very substantial. Yet, a complex array of new problems has emerged to confront the industry. Foreign challenges to U.S. technological leadership are gathering momentum. Airline earnings have declined to the point where they can no longer provide the traditional stimulus for development of new aircraft. And, research and development costs for sophisticated new equipment have climbed beyond the means of individual companies.

Charged with the legislative responsibility for civil aviation R. & D., and therefore in large part for its future directions, the Subcommittee on Aviation and Transportation R. & D. undertook a comprehensive examination of the "Future of Aviation." The purpose is to lay the basis for a national civil aviation R. & D. policy and in doing so to make a useful contribution to national transportation policy. In addition to 8 days of hearings, a number of invited papers were also solicited by the subcommittee and are compiled in this volume.

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Prof. Neil A. Armstrong,
Professor of Aerospace Engineering,
University of Cincinnati, also
advisory member of Kenton County
Airport Board, Cincinnati



April 30, 1976

Mr. Neil A. Armstrong
1739 North State Route 123
Lebanon, Ohio 45036

Dear Neil:

Attached you will find comments about the areas which Airport Staff Members believe require future study and research for the improvement of civil aviation. Those areas are as follows:

1. Environmental Control - Noise
2. Pavement Evaluation, Testing and Design
3. Security
4. Crash-Fire-Rescue Manning and Equipment
5. Bird Strikes
6. Fog Dispersal
7. Aircraft Removal

In discussing some of the economic aspects with Mr. John Brockett, his comments were as follows:

"The problems which are related to this subject and its direct immediate effect on airport operations are rather intangible, but yet in the long range directly beneficial to an airport operation. I would see basically about four areas which could directly affect the ultimate airport operation through the expenditure of R&D funds of this nature including the economic multiplier effects which might be a contributing economic factor in a given 'airport community.'"

"The expenditure of R&D funds is, in my opinion, essential to conserve the favorable competitive position which the American airline industry enjoys through the development of new aircraft and additional ground transportation methods (both on site, such as people movers, and off site through development of mass transportation systems in bringing the customer to the airport). Additionally, the expenditure of monies for the development of better methods of ground handling of equipment and baggage would also directly benefit an airport."

"Naturally, if facilities are to be constructed for this type of research and prototype work, the construction of such facilities on airport property would again directly benefit an airport operation itself if construction monies could be funneled in that direction."

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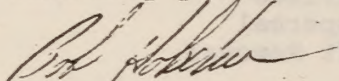
Mr. Neil A. Armstrong
 April 30, 1976
Page Two

"Another question which concerns me as much as the continuing growth of the technology of the industry, however, is the economic basis of operations of the airport industry, particularly as it might be severely restricted in the medium and smaller hub areas through the media of deregulation. This to me is one of the greatest concerns which we have today and something which hopefully R&D funds could be substituted within airport income for purposes of supporting revenue levels. In this manner the economic basis of revenue bonds would be maintained to continue the necessary updating and changing of facilities to meet current equipment requirements and current enplanement loads."

I hope that some of this material will be beneficial, and we most certainly appreciate your efforts in assisting us in getting our points to the forefront.

If you have any questions regarding the enclosed material, feel free to contact me.

Cordially yours,


 Robert F. Holscher
 Director of Aviation

RFH:mp
 Enclosures

ENVIRONMENTAL CONTROL - NOISE:

Noise pollution is the gravest problem facing airport authorities around the world. Curfews, noise abatement flying procedures and limiting operations are temporary measures which do not solve the noise problem. These measures reduce Airport capacities and inconvenience the traveling public. Therefore, NASA and the FAA should continue to further research and development in both retrofit and engine design that will assist in reducing to an acceptable level the nuisance of aircraft noise.

Further studies should be undertaken to develop zoning and land - land use controls including specific recommendations on compatible uses outside airport boundaries.

PAVEMENT EVALUATION, TESTING AND DESIGN

From a cost-benefit basis, pavement evaluation and testing with a view toward developing a rational pavement design offers considerable potential. To illustrate this need, it is important to note that since inception of the ADAP program, 55% of all Grant-In-Aid funds have been expended on runway and taxiway paving and paving-related items. In that same period less than one half of 1% of available FAA funds for research and development have been aimed at improving methods of pavement non-destructive testing, evaluation and design.

Funding of pavement rehabilitation through floating revenue bonds, is normally based on a 20-year life cycle; however, a pavement that lasts ten to eleven years is considered exceptional while seven years is more the norm. Airport pavements are deteriorating because of aircraft weights and frequencies of commercial operations. Accepted pavement design, based on highway program experience, is simply not adequate to satisfy the needs of the jet era. It is imperative that improved techniques and concepts be developed to allow today's engineer to design an operational surface which will withstand the weight and frequency of current and future aircraft.

Only in the past year has the airport sponsor, the airlines and the aircraft manufacturers been successful in calling the attention of the FAA Administrator to the cost-effectiveness of a continuing pavement R&D program.

The pavement research and development program must be structured to provide sustained annual allocation of funds that will permit the emergency of an effective non-destructive testing program and the evolution of a rational pavement design.

SECURITY

The recent bombing at La Guardia Airport which cost many lives, injuries, and severe property damage, highlights the need for expedited engineering research and development to improve the posture of aviation security. We understand that the FAA has

requested supplementary appropriations to pursue needed security research and development. We support this request and urge the Committee to recommend such appropriation.

CRASH-FIRE-RESCUE

Since implementation of FAR Part 139, Airport Certification, in mid-1973, airport authorities have been required to expend millions of the requirements outlined in this Part. In many cases meeting these requirements has caused a rise in the airport operating budget from 25% to 40%, which places the airport in a severe economic squeeze, particularly the smaller airports.

We support efforts to make air transportation the safest transportation system, and we endorse efforts to safeguard lives of air travelers. We believe, however, that the current method of requiring airport sponsors to provide a crash-fire-rescue capability based on aircraft size is arbitrarily subjecting the airport to enormous capital investment and operating and maintenance costs that are not cost-effective in light of the lives saved that can be directly attributed to airport C-F-R equipment.

Much investigation has been made of survivable aircraft accidents and alternative means of containing aircraft fuel fires. Although it is not suggested that C-F-R capability external to the aircraft should be completely eliminated, it is known that technology is available or can be made available to provide an on-board explosion prevention system that will minimize the effects of fire in the

engine area and in personnel, cargo and baggage compartments. Provision of an on-board explosion prevention system to minimize the hazards of fuel fires should reduce the need for airport/municipal authorities to purchase, maintain and operate at enormous cost, a variety of C-F-R vehicles.

We urge the FAA to continue its research into: Aircraft fuel explosion prevention systems; Safe, non-toxic compartment interior materials; The practicality of an on-board internal fire suppression system; and the Design and construction of a small, quick reaction, all purpose CFR vehicle that can be purchased, maintained and operated at minimum cost.

BIRD STRIKES

Although not widely known, bird strikes constitute a serious hazard to aviation, both in commercial and non-commercial operations. In the years 1968 through 1973, to illustrate the severity of the hazard, there were 330 U.S. Air Carrier Accidents resulting from bird strikes. Of the 330 carrier accidents, 54 aircraft were destroyed and 136 received substantial damage. There were 1273 fatalities associated with these accidents and the heavy loss of life and property continues each year.

Individual efforts by airport authorities, airlines and industry to control or minimize bird strikes has been largely unsuccessful.

In light of the severity of the hazard, we believe it incumbent on the Federal Government to diligently pursue methods to reduce this danger to a minimum.

FOG DISPERSAL

Warm fog is responsible for 95 of all the visibility restrictions and associated delays that occur at airports throughout the world. Although fog at U.S. airports occurs on the average of only 1% to 2% of the time, it is responsible for the loss in revenues of about \$100 million annually through cancellations, delays, and diversions of air carrier flights. It is necessary to seek methods to minimize the impact of fog on aircraft operations to improve aviation safety, increase airport capacity and reduce inconvenience to the traveling public through the development of operationally reliable fog dispersal systems.

Current technology is capable of developing an operationally reliable system. We urge the Committee to recommend a program for this development.

AIRCRAFT REMOVAL

A study should be undertaken to determine the technical, operational, and economic feasibility of new ground systems to significantly improve the recovery of heavy aircraft disabled or damaged at large airports. While the basic functions to be performed in the typical aircraft recovery operation have become well know, the influence of

the many variables incident to each recovery have so far frustrated efforts to institute a standardized and uniformly effective approach to the problem. As a result, the recovery of a damaged or disabled aircraft from the vicinity of an airport runway still requires a great many hours, if not days, to complete, and may cause a lengthy closure of the entire airport or a portion of it.

The intensive utilization of large metropolitan and international airports and the exceptionally high acquisition costs of modern, heavy commercial transports greatly aggravate the recovery problem. The recovery operation must be speedily accomplished to avoid extended closure of the airport and it must be conducted in such a manner that secondary damage does not occur to the aircraft. Present techniques for recovering damaged or disabled aircraft fall short of the required need, while the potential for advancing the state of the art is considerable.

STATEMENT ON
THE FUTURE OF AVIATION

by Holt Ashley
Professor of Aeronautics
and Astronautics and
Mechanical Engineering
Stanford University

This brief statement is prepared from the very individual viewpoint of a university professor specializing in aerospace, but also a person who has long been involved with consulting and with the aerospace-related government advisory apparatus.

Aviation is one of the two or three human activities where the highest demands are continually placed on applied science and technology. In the civil sector it will always provide essential transportation services for people and valuable goods — there is no superior mode to displace it in the manner that aircraft displaced ships and trains. In ways that others can explain much better than I, it provides constructive sustenance for the national economy and promotes favorable trade balances.

Against this background, it seems self-evident that all elements of society with a tradition of supporting aviation R. & D. have a future responsibility at least to maintain and preferably to increase that support; the appropriate measure is constant, not "then-year," dollars. The U.S. Government will remain unique among these elements, for the support it furnishes through such agencies as NASA and DOD far exceeds all other sources — both in magnitude and in quality. The price of abdication by Government will be a fairly swift loss of the leadership that has been painstakingly built since before World War II. I do not believe the American public will accept this loss with equanimity. Yet the price of regaining it could easily be twice that of its routine maintenance. If our resolve is adequate, foreign competition is quite incapable of overcoming our present advantage. Events like the recent sales of F-16 fighters and even of wide-bodied transports are enough to convince me.

The term "R. & D." encompasses a host of activities. But I should like to focus attention on just two of them. They are sectors closer to the "R." than to the "D." and ones where a painful erosion of "constant-dollar" support has occurred since around 1970. For the long-term future of civil aviation, I assert that they are also the two most significant.

The first sector is the in-house activity of the NASA Research Centers under the Office of Aerospace Science and Technology. By and large, the work I refer to is funded out of the category which Congress and NASA call the "R. & T. Base," but the Centers' effectiveness is also constrained when unjustified limits are placed on the number of NASA permanent professionals.

Especially in the field of fluid mechanics (but quite respectably in other such disciplines as engine materials, structural dynamics, simulation, etc., etc.), these Centers share a unique tradition of outstanding direct contributions to aviation science and technology. Names like Gilruth, Whitcomb, R. T. Jones, Garrick, Phillips, Allen, Chapman are honored "household words" throughout our profession. The military services will readily acknowledge their continuing reliance on NASA's "in-house," and with more reluctance they will admit to never having maintained comparable excellence within their own laboratories.

The degrading effects of recent budgetary trends on NASA's in-house strength must be reversed. The agency's own leadership has been deterred in recent efforts to rebuild it, more by the heavy hand of OMB than by the Congress. But given suitable Congressional urging, that leadership would, I believe, be glad to give details on how this deplorable deterioration can be countered. Furthermore, whatever corrective measures are taken by the Congress should not interfere with NASA's excellent programs of funding aviation R. & D. in the private sector.

The second sector with which I am concerned involves research and advanced education in the universities. In two June 1975 issues of Aviation Week and Space Technology, it was reported that college enrollment in aerospace engineering had declined by 70% during the preceding five years and that the number of autonomous departments had dropped from over 50 to 23. Although the former is slowly being reversed, these two trends have dangerous implications for aviation's future. With the economy beginning to recover, there are already indications of several years of higher demand for well-trained graduates than can possibly be supplied under present circumstances. Equally serious are the decimation and aging of a faculty complement which, in the 1950's and 1960's, produced a series of outstanding research discoveries far too numerous to be catalogued here.

I am not recommending a massive infusion of federal dollars which would fully restore the university aeronautical establishment to the perhaps-excessive levels of the 1960's. More modest and selective measures can, however, create levels of activity and of excellence commensurate with legitimate national needs.

Let me offer a few specific proposals with high leverage toward these ends. First, the former NASA programs of academic fellowships and design traineeships should be revived at about the maximum size achieved during the late 1960's. Second, the very effective NASA university research program should be encouraged — not necessarily with large budgetary increases but because it can hold its own when not subjected to artificial constraints or to inappropriate demands for short-term accomplishments.

A third measure, with a double payoff, would be to permit NASA and DOD aviation R. & D. activities to increase their professional manpower. The increased availability of research jobs would both stimulate more first-rate students to enter aerospace and revivify the agency's aging staff. An imaginative parallel scheme has been suggested by Col. David Scott of Dryden Research Center: a "civilian ROTC" to assist college enrollees who might contemplate federal service in aviation R. & D..

Finally, it is a matter of history that certain research-sponsoring offices in DOD have developed the most sophisticated, successful and rewarding relationships with university science and engineering to be found anywhere throughout government. In particular, the Air Force Office of Scientific Research and the Office of Naval Research deserve the thanks of the aviation community and the American public. A case can be made that the products from their grants and contracts have been and will be nearly as important to civil as to military aeronautics. Their research budgets, in constant dollars, should be restored to the levels of the 1960's.

In summary, I am confident of a bright future for U.S. civil aviation. With an eye toward its longer-term welfare, I have tried to outline a series of proposals for steps that might be taken by the Congress. As seen against the federal budget, they involve modest expenditures. Their potential payoffs are out of all proportion to their costs.

Mr. Harold S. Becker
Vice President and Treasurer
THE FUTURE GROUPS

 **THE FUTURES GROUP**

124 Hebron Avenue, Glastonbury, Connecticut 06033

The Futures Group is a research and management consulting firm specializing in future-oriented policy analysis. It was formed in 1971. Members of its staff are skilled in economics, political science, history, social psychology, physics, chemistry, anthropology, the humanities, law, statistics, systems analysis, engineering, and computer sciences. Studies are performed by The Futures Group for private and government clients in the United States and abroad.

HAROLD S. BECKER
Vice President and Treasurer
THE FUTURES GROUP

Mr. Becker is one of the founders of The Futures Group, which he now serves as Vice President and Treasurer. He is responsible for the supervision of company contracts and grants, marketing and data services. He is also involved in formulating and directing company-sponsored work of The Futures Group on systems and analytic and decisionmaking techniques and is responsible for personnel management, budgetary planning, and administrative activities of the company.

He is currently directing studies for a large industrial client on consumer purchasing patterns and household appliances. Recently he completed a study for the Federal Aviation Administration of alternative socioeconomic scenarios of conditions in the United States, the demand for air travel and approaches to policy analysis for the national aviation system. For an industrial client he conducted an investigation of energy supply and demand environment in the United States and has recently worked with NASA on a broad-based study of future technical, social, economic, and political trends which may be important to the future of space flight. A major part of this activity was related to United States and world demands for energy, food and agriculture, and non-renewable resources including the various constraints associated with making such items available for the needs of the United States. A major data service of the company, Pharmaceutical PROSPECTS, was largely developed by and the first issued prepared and marketed by Mr. Becker.

His previous research and consulting activities have included work on such subjects as the socioeconomic consequences of prepaid legal services and of legalized gambling; the future of drugs and pharmaceuticals; an assessment of the socioeconomic consequences of alternative maritime technology policies; the future of the stockholders' movement and its impact on corporate affairs; the design of mechanisms for systematically identifying and ranking promising candidates for research on the national level; the likely evolution of the agricultural solid waste management problem in the United States and its attendant threats to the environment; future prospects for use of space technologies in commercial applications; the design of studies to investigate the impact of energy demand and supply on business, the economy, and the overall quality of life; an approach to the organization of research in the area of energy by the private sector; and compilation of forecasts related to energy demand and supply and the packaging industry. Mr. Becker has authored or otherwise contributed to publications of The Futures Group on many of these subjects.

Prior to formation of The Futures Group, Mr. Becker was Treasurer and Senior Fellow of the Institute for the Future. His research at the Institute involved a number of subjects, including technology assessment and methods of improving the planning process on the community level, the latter involving a study which concerned the selection of community goals, action programs, and indicators of the progress toward goal attainment.

Prior to joining the Institute for the Future, Mr. Becker was Director of NASA's Advanced Projects Office at George C. Marshall Space Flight Center (MSFC), where he was responsible for developing goals and plans, along with specific project designs, for the national space program. These programs involved participation of all elements of NASA, various agencies of the Department of Defense, and a broad cross section of United States industry. Before this assignment, he was Deputy Director of the Advanced Systems Office at MSFC. Management and supervision of government personnel and contractor efforts were included in these activities. He was also a member of the Graduate Studies Advisory Committee at MSFC and helped design a new Ph.D. program in systems engineering and systems analysis at the Georgia Institute of Technology and lectured in the program.

Prior to his work with NASA, Mr. Becker was Director, Launch Vehicles, Advanced Systems, at North American Aviation, Inc. His responsibilities involved technical and fiscal planning and direction of systems studies on advanced reusable and expendable launch vehicles. His last assignment at North American was in the corporate offices, where he was involved with planning and evaluation of company-wide research and development.

Mr. Becker received a Master of Engineering degree from UCLA (1959) in a special program devoted to management and operations research techniques. His undergraduate degree, from the Georgia Institute of Technology, was in aeronautical engineering (1951). He has completed graduate courses in management and advanced mathematics.

In addition to the above policy analysis, planning, and advanced design activities, Mr. Becker was involved for many years in various aspects of hardware research and development. He held several positions in engineering management and as a contributing engineer for industry. Certain of these activities were quasi-government positions, especially those associated with the Air Force ballistic missile program. For The Ramo Wooldridge Corporation and later for Space Technology Laboratories, he was involved with systems engineering and technical direction of contractors developing propulsion systems for ballistic missiles. Prior to the Air Force ballistic missile program, Mr. Becker was engaged in research, development, and flight test activities at North American Aviation, Inc. on intercontinental missiles.

He has taught and lectured for industry and academia on technology assessment, forecasting, futures research, industrial planning and decisionmaking, community goals and development planning, management and organization concepts and personnel motivation techniques. The organizations for which he has lectured or taught include Columbia University, University of Connecticut, University of Hartford, The Brookings Institution, the U.S. Department of Agriculture Graduate School, State University of New York, UCLA, and Georgia Institute of Technology and various industrial firms.

Mr. Becker's publications include numerous technical papers and presentations. While at the Institute for the Future, he authored A Method of Obtaining Forecasts for Long-range Aerospace Program Planning, April 1970; A Framework for Community Development Action Planning, in two volumes, including An Approach to the Planning Process, with Raul de Brigard, March 1971. Among his earlier publications are "Adapting Space Plans to Changing Times," Aeronautics and Astronautics, March 1969 and "Space Launching Systems: Present Technology and Future Possibilities," presented at the Institute of Aeronautical Sciences, June 1962, and numerous other corporate reports and papers.

Mr. Becker's major publications since formation of The Futures Group are listed in the attachment.

(A utility company) and the Shareholders Movement: An Evaluation of the Shield's Proposals, July 22, 1971.

The Use of Cross-Impact Matrix Approaches in Technology Assessment, with Theodore J. Gordon, August, 1971. (Published under the title "The Cross-Impact Matrix Approach to Technology Assessment" in Research Management, [July 1972], pp. 73-80. Also published under the title "Utilization of Cross-Impact in Technology Assessment" in M. J. Cetron and B. Bartocha [eds.], Technological Assessment in a Dynamic Environment [New York: Gordon and Breach, 1973], pp. 663-672, and in M. J. Cetron and B. Bartocha [eds.], The Methodology of Technology Assessment [New York: Gordon and Breach, 1972].)

Prospects for Energy Utilization in the United States, A Study of Power Consumption and the Quality of Life, September 1971.

Analysis of Ailing Products--It's Decisions That Count, with Theodore J. Gordon, October 1971.

Future Energy Demand, Production, and Use: A Compilation of Forecasts, December 1971.

A Case Study and Forecast of Steel Production, Consumption, and Export by (one nation), December 1971.

A Systems Approach to Problem Oriented Research Planning: A Case Study of Food Production Wastes, January 1972.

Comments on Institutional Arrangements for Performing Technology Assessment, February 1972.

Technology Assessment Study of Socio-Economic Factors Important to the Postal Service, July 1972.

Report of Delphi Inquiry into the Future of American Water Resource Utilization and Development, with Richard G. Woods and George Patrick Johnson, (Minneapolis, Minnesota: University of Minnesota, January 15, 1973).

Future Technological and Social Changes. An Investigation of Opportunities and Threats for (a large industrial firm) As Perceived By Its Employees (Report of A Delphi Inquiry), with J. Incerti, January 1973.

U.S. Ocean Shipping Technology: Forecast and Assessment Task I Technical Report, as Project Leader of The Futures Group staff (East Hartford, Conn.: United Technologies Research Laboratories, June 15, 1973).

Democracy in America--1987, September 26, 1973.

"Technology Assessment: Another View," Business Horizons, Vol. 16, No. 5, pp. 58-60.

"Management of Risk Using Trend Impact Analysis: An Application of Computer Techniques for Corporate Planning and Decisionmaking," with H. Gerjuoy; an extension of remarks presented at the 166th National Meeting of the American Chemical Society, Chicago, Illinois, August 29, 1973.

The Pharmaceutical Industry PROSPECTS 1:1, et al., November 1973.

The Socio-Economic Consequences of Legalized Gambling: The Impact of State Lotteries and Off-Track Betting, with D. Weinstein and L. Deitch, January 1974. (Published under the title The Impact of Legalized Gambling: Lotteries and Off-Track Betting [New York: Praeger Publishers, 1974].)

The Management Dilemma: Private Profits vs. Social Responsibility: Lessons from Japan, Inc., with C. Donahue, April 1974.

"Anticrisis Management," Business Horizons, Vol. 17, No. 3 (June 1974), pp. 50-52.

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THE THRUST OF NATIONAL CIVIL AVIATION R&D POLICY
IN THE UNITED STATES:
THE ROLE OF FEDERAL FUNDING OF R&D

Prepared for

U.S. House of Representatives
Committee on Science and Technology
Subcommittee on Aviation and Transportation R&D

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ABSTRACT

This paper reviews the evolution of government support of and participation in civil aviation R&D. It summarizes the de-emphasis of aviation R&D which occurred with establishment of NASA and the dissolution of NASA. Potential DOD contributions to civil aviation also are discussed.

The diversity of interests, especially federal, which influence civil aviation R&D policy is summarized and the current inability to formulate acceptable national R&D goals for civil aviation is also treated. Recommendations are made for a way to establish goals for civil aviation in terms of socioeconomic conditions in the United States and for establishing priorities for aviation R&D on the basis of those goals.

Finally, the growing tendency for government and private sector employees to compete for federal R&D funds is described. Suggestions are made for minimizing this competition in order to foster increased motivation and creativity in the generation of technology to satisfy goals of civil aviation.

TABLE OF CONTENTS

Abstract ii

THE ROLE OF FEDERAL FUNDING OF R&D

Introduction 1
Some Conclusions and Recommendations 2
 The situation 2
 Recommended courses of action 3
The Changing Role of the Government in Civil Aviation R&D. . 4
The Contribution of Civil Aviation--Do We Know Where
 We Should Go? 13
The Role of Government--Partner or Competitor? 20

THE THRUST OF NATIONAL CIVIL AVIATION R&D POLICY
IN THE UNITED STATES

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THE ROLE OF FEDERAL FUNDING OF R&D

Introduction

Many factors will continue to influence national civil aviation R&D policy in the United States. On the one hand, they include various technologies which encompass both air and groundside capabilities. On the other hand, they consist of various socioeconomic, demographic, and institutional factors which both respond to and shape the demand for new technologies and utilization of technologies which exist. This paper is not directed at providing recommendations for specific technologies or technology programs. Rather, its intent is to discuss trends in sponsorship of R&D which is intended to support civil aviation. In particular, these thoughts are intended to spotlight some of the current and potential insufficiencies in the institutional framework associated with establishment of R&D direction and with funding and administration of R&D programs themselves.

There are many individuals and institutions in the United States intimately familiar with various aviation technologies, including those related to aerodynamics, structures, propulsion, avionics, ground systems, etc. Consequently, the Congress has no shortage of recommendations about future technologies which could be pursued, along with the specifics of their contribution to civil aviation economics, flight vehicle performance, and environmental impacts. Estimates about their potential availability and associated

costs are even available from the technologist within reasonable ranges of expectation. But not as easily available to the Congress are judgments on how and why research on these technologies should be pursued.

Man's recent journey to the moon seems to have created, within the United States, a general attitude that the technologist can provide the public almost unlimited capabilities if sufficient funds and time are allocated to stated goals. In fact, delays in curing the problems of urban decay, pollution, sickness, disease, etc., are frequently not understood by the public because of the major accomplishments of many branches of technology--especially those of the aerospace industry. But many of the problems and insufficiencies associated with current aviation R&D policy stem, not from an inability of the technologist to provide desired capabilities, but rather with the apparent growing inability of our society to properly counsel, advise and--as appropriate--provide funding support for the technologist. Goals for aviation are ill defined or nonexistent, or institutional parochialisms preclude progress. These thoughts are not offered as being exhaustive or completely comprehensive. But it is hoped that they include some concepts which will be helpful to the Subcommittee on Aviation and Transportation R&D.

Some Conclusions and Recommendations

Before discussing some of the institutional factors involved with civil aviation R&D policy, it seems appropriate to summarize the thoughts which follow.

The situation:

1. Government financial support of aviation R&D will, for the foreseeable future, continue to be necessary.

2. Institutional insufficiencies rather than shortcomings in technological capabilities are the primary constraints to improving civil aviation in the United States.

3. A recognized set of goals or objectives for civil aviation does not exist and, hence, an efficient way of establishing R&D priorities does not really exist.

4. Government sponsorship of R&D in the private sector, coupled with the accomplishment of R&D by government personnel, will increasingly create competition and hinder development of appropriate technologies.

5. DOD contributions to civil aviation are likely to be less significant over the next five to ten years than they have been in the last twenty years (especially in areas of growing concern to civil aviation such as air-side and ground congestion which cause delays and create safety problems.)

Recommended courses of action:

1. Establish socioeconomic goals for civil aviation's contribution to the United States. These targets should be expressed in quantified terms (as discussed later) to the greatest extent possible.

2. Establish R&D priorities for alternative technologies based upon the degree to which they could contribute to civil aviation's ability to accomplish the above goals and upon their estimated costs, timing and risk involved.

3. Reduce the competition between government and private-sector employees for federal funding of their individual R&D programs (i.e., restrictive institutional relationship so that government employees who participate in decisions on federal funding of industrial R&D are in lesser competition for the same funds to support their own programs.)

The Changing Role of the Government in Civil Aviation R&D

Few would dispute the fact that federal support of aeronautical R&D has had an important, if not critical, role in the successful growth of civil aviation in the United States--and around the world, for that matter. The U.S. airline and aircraft industry and other important sectors of American life have benefited economically from this growth. Possibly with the exception of the original R&D by the Wright brothers (leading to their flight at Kitty Hawk in 1903), the funds provided by the federal government and the activities of federal employees have provided a wellspring of technologies upon which the U.S. air carrier and aircraft manufacturing industry grew and prospered.

The role of the government in sponsoring aviation R&D was recognized early in the development of heavier-than-air craft. In 1907 the U.S. War Department released specifications for a military "flying machine," and two years later the United States was the first nation to possess a military airplane, the Wright Flyer, supplied by the Wright brothers. However, there was a lack of R&D follow through, and from 1903 to 1913 Italy spent 20 times more on aviation R&D than the United States, while Russia, France and Germany spent more than Italy. But foreign R&D was actually based on U.S. prototypes and concepts.¹ The United States recognized early the need to support aeronautics R&D and the National Advisory Committee for Aeronautics (NACA) was established on March 3, 1915 via a rider to the Naval Appropriations Act. The purpose of the NACA was "to supervise and direct the scientific study of the problems of flight, with a view to their practical solution."

¹U.S. Congress, Policy Planning for Aeronautical Research and Development, 89th Congress, 2d Sess., Committee on Aeronautical and Space Sciences, U.S. Senate (Washington, D.C.: U.S. Government Printing Office, 1966), p. 23.

Funds of \$5,000 per year for 5 years were appropriated at that time for the NACA. This funding ceiling was soon removed, as in 1917, \$87,515 was provided to the NACA as part of the Naval Appropriations Bill. The need for the NACA to engage directly in large-scale testing and experimentation was recognized, as this 1917 appropriation included \$69,000 for laboratory construction at Langley Field, Virginia. Indeed, from that point until its inclusion in the National Aeronautics and Space Administration (NASA) in 1958, the annual funding of the NACA increased essentially each year, as shown in Table 1. Early in 1917 the NACA obtained the status of

Table 1

SUMMARY OF FUNDS APPROPRIATED TO NACA, FISCAL YEARS 1915-59

1915	\$ 5,000	1938	\$ 1,280,850
1916	5,000	1939	4,063,980
1917	87,515	1940	4,180,000
1918	112,000	1941	11,200,000
1919	205,000	1942	19,865,910
1920	175,000	1943	25,428,736
1921	200,000	1944	38,392,215
1922	200,000	1945	40,942,330
1923	225,600	1946	24,014,393
1924	307,000	1947	30,713,000
1925	470,000	1948	43,449,000
1926	534,000	1949	48,652,000
1927	513,000	1950	128,000,000
1928	550,000	1951	63,068,000
1929	836,770	1952	69,000,000
1930	1,300,000	1953	66,286,100
1931	1,321,000	1954	62,439,000
1932	1,051,070	1955	56,860,000
1933	920,000	1956	72,700,00-
1934	709,250	1957	78,620,500
1935	766,530	1958	117,276,209
1936	2,544,550	1959	101,100,000*
1937	1,630,550		

*NASA took over all NACA assets and unexpended funds in September 1958. In addition there was appropriated for NASA in fiscal year 1959, \$229.1 million making a total of \$330.9 million for the new agency.

Source: U.S. Congress, Policy Planning for Aeronautical Research and Development, 89th Congress, 2d Sess., Committee on Aeronautical and Space Sciences, U.S. Senate (Washington, D.C.: U.S. Government Printing Office, 1966), p. 166.

an independent agency, and from that point it operated in close harmony with American industry. In April 1918 plans also were approved for construction of the first wind tunnel, a five-foot diameter facility, at Langley Field, Virginia. Following World War I, the federal government dominated aeronautics R&D and actually owned and operated several production facilities. Indeed, it was the sole customer of the output of civilian aircraft factories.

In March 1920 the NACA proposed a national aviation policy to, among other things, 1) extend use of its facilities and personnel to industry and universities in order to further R&D work outside the government, 2) expand air mail service, and 3) authorize airplane competition to stimulate major new designs. Cooperation with industrial efforts continued, and in 1921 the NACA distributed over 20,000 copies of various technical reports and notes to government, industrial and educational organizations.² Even from these earliest years, however, government activities were not centralized in that agency. In its 1924 annual report, the NACA Committee on Aerodynamics noted that, in addition to its own direct control of R&D at Langley and at Stanford University, it also was receiving reports from the Washington Navy Yard Aerodynamics Laboratory, Engineering Division of the Army Air Service, and from MIT. It billed itself as "in close contact with all aerodynamical work being carried out in the United States."²

In spite of its apparent overview of aeronautics R&D activities in those early days, there seems little to indicate that there was any significant structure to the programs coming from a set of national goals or purposes for aviation, from either a federal or private sector viewpoint. The first

²Ibid., p. 39.

directive with any semblance of a national focus seems to have appeared with the Air Commerce Act of 1926 which instructed the Secretary of Commerce to foster air commerce; designate and establish airways; establish, operate and maintain aids to air navigation; arrange for R&D to improve such aids; license pilots; issue air-worthiness certificates for aircraft and components; and investigate accidents. The enactment of this Act was not coincidental, as scheduled commercial air service began in 1926 with 5,782 passengers carried that year. By the middle of the 1930's, this figure had risen to about 462,000 passengers; and by the early 1940's, to over 4 million.

The ability of commercial air services to operate with any semblance of economic viability was markedly supported by federal funds, including subsidies for carrying mail--and, of course, through the technological contributions flowing from work of the NACA. In 1928 the NACA developed the first cowling for radial air-cooled engines which increased the speed of the Curtis AT-5 from 118 to 136 mph. with no increase in horsepower. The NACA was providing data for industry and the military on locations for fairing engine nacelles into the leading edge of wings to increase performance. It also demonstrated the impact of boundary layer control on lift. The NACA technical reports were viewed as being "gospel" during the 1920's and industry relied on them for data and technical advances.³ The early boundary layer control work was followed in 1932 by publication of a comprehensive report on the derivation and the characteristics of airfoils. This systematic delineation by the NACA of airfoils proved to be the standard upon which many civil and military aircraft relied for many years.

³Ibid., p. 40.

In 1935 another step with a national overview was taken when the President's Federal Aviation Committee recommended a broad policy in all phases of aviation, including strengthening commercial and civil aviation, expansion of Air Force facilities, establishment of more realistic procurement practices with industry, and the study of closer governmental inter-agency relations--including expansion of experimental and developmental work and better coordination with the NACA. By the end of the 1930's, the NACA facilities were expanded markedly when in December of 1938 a special committee on "future research facilities of NACA" recommended what in effect became the Ames Aeronautical Laboratory at Moffett Field, California. Another committee, on the same subject and headed by Charles A. Lindbergh, recommended that a power plant research center be established immediately which resulted in the Aircraft Engine Research Laboratory at Cleveland, Ohio. This facility, established on June 26, 1940, is now known as the Lewis Research Center.

The close relationship between civil and military aspects of aviation continued to be recognized when, in October 1940, Congress appropriated \$40 million for construction, improvement and repair of up to 250 public airports, as it was determined that such work was necessary in support of national defense. By the end of 1942 an additional \$159.6 was appropriated for what was then 504 sites. Research facilities at Langley and Ames Laboratory were doubled with new construction, also for "defense applications."

Coordination and direction of civil aviation, and of organizations which influenced aviation R&D, probably began in earnest about 20 years after the creation of the NACA. The Civil Aeronautics Act of 1938 coordinated all non-military aviation under the Civil Aeronautics Authority (CAA), whose purpose

was to foster civil aviation and regulate air traffic. Reorganization of the CAA occurred in 1940 with creation of the Civil Aeronautics Board (CAB). In 1946 a National Aeronautical Research Policy was formulated by the AAF, the Navy's Bureau of Aeronautics, CAA, NACA, and the aircraft industry. This policy was created largely to clarify relationships among NACA and other R&D agencies. The statement charged NACA with responsibility for "research in the aeronautical sciences," the military services with "the evaluation of military aircraft and equipment and the exploration of possible military applications of research results," the CAA with "expediting the practical use of civil aeronautics of newly developed aircraft and equipment," and the aircraft industry with "application of research results in the design and development of improved aircraft equipment, both civil and military."⁴

The increasing importance of government sponsorship of aviation R&D in the United States was recognized again when, in 1949, the Unitary Wind Tunnel Act authorized construction of additional NACA facilities, wind tunnels at universities, a wind tunnel at the David W. Taylor Model Basin, and establishment of the Air Force Arnold Engineering Development Center at Tullahoma, Tennessee--because of the "recognition of the fact that industry could not subsidize expensive wind runnels for research in transonic and supersonic flight." Concerns about inadequacy of U.S. capabilities further prompted Congress in 1950 to ask for "the development of improved transport aircraft, particularly turbine powered aircraft, aircraft especially adapted to the economical transportation of cargo and aircraft suitable for feederline operations." The Prototype Aircraft Act of 1950 appropriated \$12.5 million

⁴Ibid., p. 41

over 5 years to this end but, as some have noted, the funds were never used due to lack of industry support.⁵

The institutional framework for federal support of civil aviation R&D, and the direction of that R&D, was markedly altered when President Eisenhower in 1958 signed the National Aeronautics and Space Act creating NASA. It was noted that "the qualities of leadership and the technical excellence achieved by the NACA made it a logical choice in 1958 to serve as the nucleus of the organization to carry out the national space mission."⁶ Many arguments have been raised that this single step largely relegated federal interest in aeronautics, and in particular civil aviation R&D activities, to a much de-emphasized role. In 1958 the NACA appropriations had totalled \$117 million, but the estimated 1976 budget plan for aeronautical research and technology within the NASA program, in constant 1958 dollars, totals \$86,379,000--a 26% reduction in real terms.⁷ As observed by many, the role of aviation technology within the NASA federal agency seems best described by designating that agency as The NATIONAL Aeronautics and SPACE ADMINISTRATION. NASA funding of aeronautical research and technology over the past several years has averaged about 7% of the total NASA budget, and in recent years has actually declined, dropping from 7.3% in 1974 to an estimated 7.1% in 1975 and an estimated 6.5% in 1976.⁸ The argument has been made that space has prospered at the expense of aeronautical advancement.

⁵Ibid., p. 34.

⁶Ibid., p. 42.

⁷Assumes a 6% inflation rate of the GNP price deflator for FY 1976.

⁸Executive Office of the President, Office of Management and Budget, The Budget of the United States Government, Fiscal Year 1976 (Washington, D.C.: U.S. Government Printing Office, 1975), p. 799.

The two tasks assigned to NASA, the civilian exploration of space and continuing research into aeronautics (originally performed by the NACA) clearly were not identical in scope. But the type of contribution to aviation which had been provided by the NACA has not continued. Several reasons may be offered. NACA worked well with both industry and the military because its mission was research, which was clearly complimentary and not competitive to either the industry or the military. NACA possessed few aircraft and did not let R&D contracts of any significance. It had well-equipped laboratories and, hence, attracted excellent scientists and engineers who contributed important advancements to the state-of-the-art with no specific requirement that these innovations and their data have a mission application. Indeed, for 40 years the NACA responded quite reliably to requests from industry and various defense agencies for aeronautics information. NACA facilities were often unique. With the creation of NASA and the emphasis on space flight, aeronautical research functions under the auspices of NASA were largely overshadowed by the important mission orientation of its space flight activities.⁹

It has been argued that as NASA emphasis on aeronautical R&D declined, major benefits from military activities were forthcoming. In the recent CARD study, it was stated that "the present study of this problem (transfer of technology between military and civil aviation) revealed no lessening in the funding provided by the military to support aeronautical research and development, and it appears that there will be no major reduction in the benefit

⁹U.S. Congress, Policy Planning for Aeronautical Research and Development, pp. 167-168.

military R&D provides to civil aviation."¹⁰ This view, however, is disputed by many who argue that there has been a growing divergence between military and civil requirements for aeronautical R&D. One major factor behind this divergence is Public Law 91-441 which limited the degree to which R&D by the private sector could be reimbursed by the military as part of a company's independent research and development program if it did not have rather direct DOD applications. Nevertheless, few would argue that equipment in operation by the air carriers have benefited markedly from propulsion developments and other military work in structures, aerodynamics, and electronics and communications. Indeed, the DOD expenditures for aeronautical R&D during the bulk of the 1960's exceeded that of NASA by more than a factor of 10, with Air Force expenditures themselves exceeding those of NASA by the bulk of this amount.¹¹

But it seems likely that civil aviation's future problems may, for the next several years, receive decreasing benefits for military R&D. Problems of air and groundside congestion and traffic delays and mid-air collisions are increasingly troublesome to the public and air carriers. It is not clear that DOD will center much significant effort on these areas.

The institutional framework and the factors involved with influencing civil aviation R&D have become increasingly complex and fragmented. At the same time that aeronautics activities apparently were being submerged within

¹⁰U.S. Congress, Civil Aviation Research and Development: Policies, Programs and Problems, 92d Congress, 2d Sess., Subcommittee on Aeronautics and Technology of the Committee on Science and Astronautics, U.S. House of Representatives (Washington, D.C.: U.S. Government Printing Office, 1972-1973), p. 110.

¹¹U.S. Congress, Policy Planning for Aeronautical Research and Development, Table 49, p. 170; Table 51, p. 182.

the NASA framework, there has been a continued proliferation of government agencies which, in one way or another, influence and control funding of civil aviation R&D. Elements of NASA, FAA (created in 1958), CAB, and DOD are involved. And federal programs that influence civil aviation do not stop there. The Department of Commerce, the Department of Housing and Urban Development, various offices of the Department of Transportation (of which FAA is a part) including the Federal Highway Administration and the Urban Mass Transportation Administration, and the Environmental Protection Agency all impact the direction and utilization of technologies associated with civil aviation in one way or another. Each one of these agencies and departments largely has its own goals and objectives--and its view of the role of civil aviation in American life.

The Contribution of Civil Aviation--Do We Know Where We Should Go?

With such a diverse set of viewpoints impacting on civil aviation policy, it is hardly any wonder that many are frustrated by their inability to perceive an adequate thrust and direction to civil aviation R&D--or, for that matter, to perceive a semblance of any real policy at all. The House Subcommittee of Aeronautics and Space Technology of the Committee on Science and Astronautics concluded in its 1970 report that reasons for concern existed about the United States maintaining its long-held world leadership in aviation. The report of the Subcommittee expressed the need for a National Aviation Plan, and, as a result of the 1972 hearings, largely repeated the same concerns. In 1972 the Subcommittee concluded that the United States, although still maintaining its world leadership, was rapidly losing its position in world aviation. It referred, among other factors, to the

determination of foreign nations to penetrate the world aviation market. The Subcommittee stated that "...the United States currently enjoys a dominant but threatened position of world leadership in aviation. Further, it is evident that the United States has on the record in various forms an explicit objective to retain this world leadership role."¹² In its January 1973 report, the Aviation Advisory Commission also strongly voiced the need for a comprehensive National Aviation Plan. And the debate today seems largely unchanged--a plan is still being sought.¹³

Reports of such hearings and studies, which are typical of statements expressed, do not specify the criteria for measuring world leadership in aviation--or for that matter, the nature of the contribution civil aviation should really make to the nation. Clearly, leadership as viewed by each of the agencies and organizations which ultimately contribute to the shaping of national aviation R&D policy are varied. It is not clear that these organizations agree as to what the measures of such leadership are or should be and, possibly more important, as to what would really constitute adequate levels or values of such measures. As the Aviation Advisory Commission on The Long Range Needs of Aviation reported in January 1973, "Simply put, aviation has no single home."¹³

Thus, although we are dissatisfied with and frustrated about the status of R&D in support of civil aviation, there is no clear and accepted objective-oriented statement of the type and level of R&D which should be pursued. But

¹²U.S. Congress, Civil Aviation Research and Development: Policies, Programs and Problems, p. 48.

¹³Aviation Advisory Commission, The Long Range Needs of Aviation: Report of January 1973 (Washington, D.C.: U.S. Government Printing Office, 1973), pp. 35 and 33.

without the existence of a single recognized authority for aviation policy, the current approach to budget setting is, and by necessity must be, based upon our system of compromise among the divergent interests involved. Clearly, two types of technology are desired by those involved with shaping aviation policy. On the one hand are those technologies which are directed primarily at enhancing the economic return to the aircraft industry and the air carrier. These technologies are typically associated with increasing system performance of one form or another, and/or reducing costs. Other technologies are associated with removing or minimizing various undesirable impacts of air travel such as noise and air pollution. In the case of those who operate civil aviation systems for a profit, the former areas of technology represent those which are continually desirable. The second category of technology (associated with reducing environmental and other undesirable aspects of aviation) often is perceived by operators as detracting from their ability to maximize profits, and in some cases this technology is viewed as making it largely impossible to maintain any level of profitability at all. Hence, such technologies are not really "requested" by operating companies and are often resisted by the commercial operator. These technologies find a place in the commercial market largely due to operating constraints established through legislation, which thus creates the need for acceptance of them.

With such conflicting views of technology, it seems appropriate, or really necessary, to seek some form of "worth criteria" for alternative future technologies--criteria based upon the needs and desires of the users of such technology. Hence, technologies could be assessed on their ability to contribute to both the objectives of the private and public sectors. But such an approach would require specification of the degree to which civil aviation

can and, more importantly, should contribute to the nation's well-being. Clearly, such an approach can be viewed by some as tantamount to institutionalizing a highly managed or "big brother" society. There currently is no shortage of opinion about the degree to which demographic, socioeconomic, and ecological conditions in the United States can and should be managed and regulated by government.

Arguments supporting increased governmental regulation and management of the national aviation system (and other high technology areas) are based upon the increasing complexity of our society, both domestically and internationally, coupled with the increasing impact which some technologies already have had and in the future are likely to increasingly have upon us. Alternate arguments point out that the well-being of Americans, and for that matter the rest of the world, can only be assured by a return of the United States to a bottom-line, free enterprise motivation, on the premise that such a framework is most conducive to creative and innovative thought.¹⁴ It seems sensible to recognize that, at least for the next one or two decades, neither position will prevail and that a compromise between them will prove to be the most tractable approach. Rather than "manage technology," it may be more appropriate to establish specifications defining the characteristics desired of our systems of transportation. Of course, such specifications can and really should be time variant, i.e., the "worth criteria" can become more or less demanding as conditions warrant. Indeed, if we cannot prepare such specifications for the technologist, we will indeed be hard pressed to assess the technologies he proposes.

¹⁴Macrae, Norman, "America's Third Century," The Economist (October 25, 1975), pp. 3-44.

Clearly, such a set of socially relevant specifications cannot be prepared quickly and easily. The government, either the executive or legislative branch, or perhaps both, for the next five or ten years might be the natural catalyst for providing such criteria--but participation of the industrial sector should be an integral part of such deliberations.¹⁵ The ability to quantify desired contributions of civil aviation for our nation's socioeconomic well-being was addressed by Booz, Allen Applied Research, Inc. in the early 1970's. In its study, Booz, Allen included an estimate of the contribution of civil aviation to the gross national product of the United States. It considered such factors as direct salaries, generation of profit, and government tax revenues. The calculation estimated direct and the induced contributions from civil aircraft manufacturers and certified route air carriers.¹⁶ From the data presented in the study, it appears that from about 1950 to the end of the 1960's, civil aviation's contribution to GNP increased from about .2% to almost 1%, increasing about .2% every 5 years! As the report includes levels of employment in civil air transportation and related industries, impacts on balance of payments, levels of various forms of pollution and various measures of productivity of air transportation, it demonstrates in primitive fashion how various technologies contributed to these "socioeconomic conditions."

¹⁵For a somewhat more complete discussion of this approach to technology assessment, see Becker, Harold S., "Technology Assessment: Another View," Business Horizons, Vol. 16, No. 6 (October 1973), pp. 58-60.

¹⁶Booz, Allen Applied Research, Inc., A Historical Study of the Benefits Derived from Application of Technical Advances to Civil Aviation, Vol. 1, Summary Report and Appendix A (Detailed Case Studies) for the Joint DOT-NASA Civil Aviation R&D Policy Study (TST-30), Department of Transportation DOT TST-10-2/NASA CR 1808 (Springfield, VA: National Technical Information Service, February 1971).

If we already have been able to historically relate GNP, employment and other economic factors to various features of air transportation, it seems reasonable to postulate that future socioeconomic contributions of civil aviation can be spotlighted and technological features of air transportation at least partially described in light of those targets. For example, many government and private-sector organizations continuously provide projections of GNP. Although such projections are hotly debated, it seems reasonable to expect that at least an acceptable range can be established upon which civil aviation goals might be established. Targets could be described for civil aviation's contribution to GNP, which in turn could be translated into levels of activity for air transportation. The adequacy or inadequacy of technology to support such activity (e.g., to provide employment, foreign sales) along with established targets for noise, pollution, safety, etc., would provide much clearer insight into preferred areas of technological endeavor.

Some initial work along such lines was recently accomplished for the FAA. It depicted alternative scenarios of demographic, social, economic and life-style conditions in the United States which influence air travel. National levels of air travel and air traffic at certain regions and airports were estimated under those conditions so that the adequacy of aviation technological (and other) policies could be assessed.¹⁷ In the normative scheme proposed here, one or more scenarios representing desired conditions could be selected and alternative aviation technologies which best contribute to those conditions could then be spotlighted.

¹⁷ Becker, Harold S., et al., Alternative Future Scenarios for the National Aviation System, Report 174-72-01 (4 volumes), Vol. 1, Executive Summary; Vol. 2, Alternative Scenarios; Vol. 3, Scenario Construction Methodology; Vol. 4, Implications of Advanced Aircraft Technology (Glastonbury, CT: The Futures Group, September 1975).

Is it possible that debates on such subjects might illuminate values associated with the number of jobs a union is willing to sacrifice--or what level of reduced earnings stockholders will find acceptable if certain restrictions are placed upon operations at a given airport to maintain various noise and pollution levels with a given level of technology? For example, levels of employment in various industries directly and indirectly linked with civil aviation could be estimated based upon various levels of air travel associated with the selected scenarios as a means of assessing R&D policy.

As noted earlier, preparing objectives or specifications for civil aviation will not be easy. Among other difficulties, it embraces the concept of coming to grips with value changes in our society. In other terms, it requires an attempt to estimate today what tomorrow's generations will hold as desirable and acceptable. Certainly, this seems to fly in the face of a great deal of man's experience. That which was valued yesterday is often damned today, and today's levels of satisfaction will not satisfy tomorrow's needs.¹⁸ The point here would be to raise part of the Congressional debate on allocations and appropriations for civil aviation R&D from the level of specifics about given technologies to discussion of the potential contribution of civil air transportation to socioeconomic conditions in the United States. Technologies which can contribute to desired socioeconomic conditions could then be more effectively spotlighted.

¹⁸Becker, "Technology Assessment: Another View," pp. 58-60.

As noted in the recent CARD study: "In the future, civil aviation's role as a contributor to social goals of the nation will become increasingly important. Civil aviation's contribution will depend upon its ability to influence regional development, to affect favorably population distribution, and to aid in conserving land resources. Both a broader approach to R&D and an adjustment in the regulatory environment will be necessary for civil aviation to make these contributions effective."¹⁹ It now appears appropriate and necessary to seriously consider increasing the degree to which we quantify such contributions of civil aviation to social goals if we are to improve our approach to setting R&D policy.

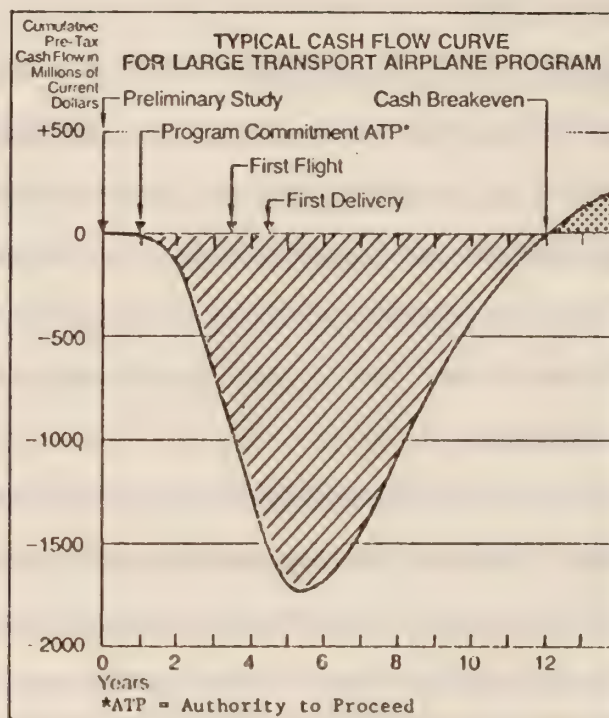
The Role of Government--Partner or Competitor?

Even if such goals or worth criteria were to be established, can the government, through funding of civil aviation R&D, effectively contribute in the national interest? There seems little question that support of civil aviation R&D by the federal government is really a necessity. Questions are largely associated with what forms that support should take and what areas of technology should be supported.

The allocation of federal funds for support of civil aviation R&D can, of course, take two forms. Federal funding can support work done within the private sector. On the other hand, it can support construction, staffing and operation of government-owned facilities. In the former case, funds can be applied through contracts, reimbursements of independent research and development activities, or possibly through tax benefits and credits for socially

¹⁹U.S. Congress, Civil Aviation Research and Development: Policies, Programs and Problems, p. 56.

contributory and beneficial technologies.²⁰ In any event, such support is viewed as reasonable because of the market risks to the developer and manufacturer, the large cash investments associated with current and future levels of technological development programs, and, as a result of these two factors, the inability to raise capital in the public marketplace. Indeed, the risks to the private sector are not insignificant, as the economic break-even point for large transport aircraft has been estimated to be in the order of 10 years, as shown in Figure 1.



Source: Aviation Advisory Commission, The Long Range
Range Needs of Aviation: Report of January 1973
(Washington, D.C.: U.S. Government Printing
Office, 1973), p. 27.

Figure 1

²⁰Becker, "Technology Assessment: Another View," pp. 58-60.

But whether federal funding provides support of private-sector activities or operation of government facilities, the institutional arrangements involved with such activities can either enhance or inhibit competition between the public and private sectors. In the days of the NACA, the open dialogue and free exchange of data clearly proved effective in expediting generation and beneficial exploitation of technology. Of course, government participation in development of technologies for the civil sector are widespread around the world. The British, French, and West Germans have and continue to provide government sponsorship for technologies which are employed in the "private sector." The Soviet and Japanese governments also provide direct support for civil aviation R&D. But unless we are to nationalize our aviation industry, the "working relationships" between industry and government will continue to importantly influence the effectiveness of federal spending on civil aviation R&D--and the degree to which it actually contributes to the private sector and to creation of a healthy civil aviation system in the United States.

Government sponsorship of R&D creates difficulties which influence the motivation and creativity of private companies. One of these difficulties is the inability of private organizations to maintain a proprietary interest in government-supported technologies.

And growth of government-accomplished R&D, especially under the auspices of NASA programs seems to have engendered a growing spirit of competition between scientists and engineers in the public and private sectors. Government employees often seek out ideas for new technologies from the private sector but are reticent to share insights, as such insights are employed to justify federal budget requests for R&D programs which maintain employment levels at

various government centers. The search for personal recognition in the pursuit and development of technologies is not an insignificant factor in inhibiting communications about and exploitation of technology. Clearly, this environment is markedly different from that which existed during operation of the NACA. In that era, the relationship of industry to government was rather different from our current situation. Industry openly sought the aid and advice of NACA researchers who, in turn, freely offered their opinions and widely published NACA reports. As recently noted, "Today when a problem arises, it is recognized as an opportunity for a sale of a research project, rather than as a matter to be brought to NASA for solution."²¹ Although it has been observed that "this competition between NASA intramural research centers and industrial laboratories is not necessarily detrimental to aeronautical progress,"²¹ it has been the observation of this author, from both government and private-sector employment, that the nature of such competition has an inhibiting effect on communications among those involved in structuring and pursuing civil aviation R&D. And this effect is more significant than we would like to accept or have been led to believe.

Indeed, the motivation, dedication and capabilities of persons working in technical and scientific activities of government are largely the same as those working for industry. And the opportunity for a "sale of a research project" exists in the mind of both the government employee and the private-sector employee--and both are seeking employment. The point here is to spotlight what, in fact, could be a significant inhibitor to improving approaches

²¹U.S. Congress, Policy Planning for Aeronautical Research and Development, p. 168.

to civil aviation R&D policy in the United States with the hope that mechanisms can be established to minimize institutional barriers which have been created, often unknowingly. Such mechanisms might include reducing the participation of government employees in decisions on federal funding for industrial R&D in areas where those government employees are competing largely for the same funds. Alternatively, changes might be made to reduce the degree to which government personnel accomplish R&D that can be done by the private sector. Of course, a combination of these approaches may also be viable.

May 21, 1976

FUTURE DEVELOPMENT OF AIR TRANSPORTS

by
John G. Borger

Mr. John G. Borger
Vice President and Chief
Engineer, Pan American
World Airways, Inc.

Introductory Note:

The views herein are those of the writer. Obviously, much of the knowledge and experience reflected in such views has been gained during his employment by Pan American World Airways since 1935, but the statements herein cannot be considered to reflect an official position of Pan Am.

Within a lifetime, we have seen remarkable transitions in our primary modes of transportation. The Queens of the Sea are lying at docks, waiting for the salvaging cutting torch. The luxurious limiteds and express trains are no more. Sea and rail shipping of freight are still strong, particularly of bulk cargo, but trucking on one side and air transport on the other are whittling away on the carriage of mixed cargo loads.

Andre Priester, the first Vice President and Chief Engineer of Pan Am used to put it this way: "Speed is the prime commodity of air transportation". Reduced time of transit, of course, has been our main objective through the years, but on the way we have also learned to produce safe operation at reduced costs, to achieve lower cost per seat mile - or per ton mile. This combination of speed and competitive costs with safety, has resulted in the disappearance of passenger vessels and limited trains. This is the kind of transportation the passenger and shipper want.

The most influential factor in the achievement of higher speeds and lower unit costs has been the development of superior airplanes. Productivity has multiplied many times, as shown in Figure 1.

Over the past 45 years, U.S. transport airplanes have become the best in the world. Starting with the Boeing 247 and Douglas DC-2 in 1933-34 including the famed DC-3, Boeing 314 Clipper, the DC-4, Lockheed Constellation, the DC-6 and its magnificent successor, the DC-6B, through the early B-707 and DC-8 jets to our present wide-bodied B-747's, DC-10's and L-1011's, plus the shorter range B-727's, DC-9's and B-737's, there have been few challenges to American transport airplane supremacy. The exceptions have been the Comet, the Viscount, the Concorde and possibly the current A-300B.

How was this superiority achieved? What follows is one interested observer's concept.

First, the United States formed an ideal geographic, economic and political base for development for an air transportation system. Distances between cities are great enough to demonstrate the benefits of air transport speed. Airlines could develop for the most part free of Government controls - or interference - except with regard to routes, fares and safety. Competition between airlines developed not only with respect to equipment and operating speed, but to lower cost per passenger mile. (The jet program did not go forward until the airlines were assured that operating costs per seat mile would be less than those for the DC-6B.) As long as airlines were reducing fares, there was little Governmental interference.

Development of America's international air routes brought on a need for different airplanes. First it was amphibians, then flying boats to connect the two American continents, primarily because of the scarcity of suitable airports. Then, as the oceans were challenged, the need for longer range airplanes developed. With the

building of airports brought on by World War II, the flying boat was no longer economically competitive. (In the pre-war period, Pan Am had always operated just about the same number of land planes as sea planes.) But the overseas airlines have continued to need longer range airplanes than the purely domestic airlines - the latest example being the development by Boeing of the 7,000 mile 747SP to joint Pan Am/Boeing specifications. Probably the most influential factor in transport airplane design is the route structures of customer airlines.

Competition among the aircraft and engine manufacturers has always existed. Boeing 247's vs. Douglas DC-2's and -3's. Lockheed Constellations vs. Douglas DC-4's and -6's; Boeing 707's vs. Douglas DC-8's. And now Boeing 727's and 737's vs. Douglas DC-9's; Douglas DC-10's vs. Lockheed 1011's vs. Boeing 747's. Pratt & Whitney vs. Wright Aeronautical. Now Pratt & Whitney vs. General Electric.

Competitive free enterprise has invariably produced better airplanes and engines (the writer was direct participant in simultaneous development of the B707 and DC-8). In competitive airplane development however "three's a crowd", for whenever three manufacturers competed to produce essentially the same article, one was hurt badly.

Other important factors in the development of superior airplanes have been development of superior engines, and a very close builder-operator relationship.

It is a truism in the airplane business that if you don't have a good engine, you don't have a good airplane. Since the 1920's American

engines have led the way, challenged only by the British, and before World War 11, by the Germans. We have always had a strong, healthy and technically innovative engine industry, and all signs point to a continuation. More so than their airframe counterparts, the engine manufacturers have been able to translate technical knowledge, tooling and other derivatives usually including early operating experience from military engine programs into commercial programs, even though there are many differences between military and commercial engines.

A unique feature in the development of American transport airplanes has been the close relationship between the designers/builders and the ultimate operator. A transport airplane is a very complex combination of machinery, which must operate in harmony for thousands of hours and flights. By working together, the manufacturer and operator solve many operating problems long before the airplane goes into operation. The importance of this cooperation cannot be minimized.

Sound basic research by NACA and its successor NASA has been translated by the manufacturers into operating airplanes. All of the manufacturers have found it advisable to have their own research facilities, but these are usually more specialized and used for testing specific configurations and design refinements.

It is most important that NASA continue with its basic research which undoubtedly will carry over into some generalized applications. But it is not believed that NASA should dilute these efforts by crossing the rather vague dividing line into configuration design.

The manufacturers are better equipped to handle this phase because they are more familiar with manufacturing requirements and customers' desires, and they must bear the ultimate designers' responsibility.

Heretofore, there always has been sufficient capital available to finance private development of commercial transport airplanes. But as technology advances, and under the influence of inflation, costs have been increasing. Figure 2 shows the trend over the years (accuracy of some of the individual points may be questionable, but the overall trend is a close representation of actuality).

Reported development costs of the Concorde represent a dramatic example of this trend, but they have unquestionably been inflated by the extremely long development period - over 13 years - and possibly by some redundancies.

Now we have a new problem: financial health of the customers. Almost all airlines have encountered serious financial difficulties over the past few years, with the result that they do not have the funds available to order replacement or new airplanes. The banks and other financial institutions have become increasingly wary of making such funds available through loans or other financing. And there's little incentive for any manufacturer to make a sale if he's not sure how or when he's going to get his money.

The result has been a dearth of new orders. Boeing and Douglas have been subsisting primarily on orders from foreign airlines, Lockheed has not announced a new order for some time.

Meanwhile, there is a real need for new equipment. Early B707's and DC-8's are now 15 years old or more. Their normal technical

obsolescence has been given an added push by the rise in fuel price from an average of 11 cents per gallon to 40 cents.

There is considerable pressure from the public to make the airplane quieter, and pressure from the EPA to reduce emissions from turbine engines. It may even be possible to achieve small improvement in direct costs per seat mile, although this will be most difficult not only because of the increased fuel cost, but because of increased labor rate costs and increased airplane prices.

NASA is undertaking a long range program targeted at achieving improvement in aircraft energy efficiency in the order of 50% by 1985. This is a good program, its success should assure continued technical superiority of American transport airplanes even though the results will ultimately become available to all aircraft manufacturers. To realize the full benefits of this program however, entirely new airplanes and engines will have to be designed, developed, tested and built, which means availability for service not less than 10 years from now.

But the knowledge is already in hand to realize about half of the overall improvement in aircraft and engines derived from existing designs. Derivation designs should not cost as much to develop. Example: The B747SP development cost was much less than half that of the B747, in spite of inflationary effects. Such derivative airplanes could be less noisy, and certainly less costly to operate than the older jets they could supplant. The manufacturers are reluctant to undertake such programs because of lack of customers with money to finance even these reduced development costs.

It therefore appears that the first prerequisite to renewed production of superior airplanes, and the overall health of the aircraft manufacturing industry is restored financial health of the customer airlines, and confidence of the financial community in future health of the airlines.

To the writer, the most pressing need for new airplanes is replacement for B707's and the older DC-8's, as mentioned earlier. Some replacements probably will be provided by B727-200's, some by B747SP's/DC-10's/L-1011's. But there does appear to be a need for a 180-200 passenger airplane with something like 3500-4000 nautical miles range.

The biggest potential market for replacement airplanes will be for successors to the remarkably successful B727's. But these are going to be more difficult to improve upon; the successors probably should incorporate some of the energy efficiency improvements from the NASA program, if they are ready in time.

People have talked for many years about designing an airplane optimized solely for carrying cargo. The trouble with this concept is that the potential market for such an airplane has been, and is expected to continue to be, too small to justify undertaking a program, particularly if the airplane is to be much bigger than the B747F. An exercise should be undertaken to determine if such a design could really be better than an improved derivative B747F. Certainly a more efficient cargo carrier can and should be developed.

We are also seeing the first operation of a supersonic transport. The Concorde certainly achieves the primary objective of improved speed, but whether supersonic flight times are attractive enough to overcome the accompanying compromises in operating costs, comfort level, noise and other environmental effects remains to be seen. Assuming Concorde does not fail, it is believed that SST flight times will ultimately be demanded by a large portion of airline passengers, and all major international airlines will have to provide SST service. We now know that a safe and environmentally acceptable SST can be built, but whether operating costs can be competitive is still subject to proof. There exists a large question regarding SST economics, particularly under current financial conditions. Much more evidence is needed before commitment to a program can be justified.

In the long run, it is believed we should continue to stress improvements in direct cost per seat mile (or per ton mile). Improved energy efficiency probably will be most influential in achieving such lower costs, although the traditional approach of improving the payload carrying capability of the airplane cannot be neglected.

It is believed that more seats can be added to existing passenger airplanes, and more tonnage capability to cargo airplanes, but whether airplanes with larger fuselages will be built probably will be dependent on a more favorable market atmosphere.

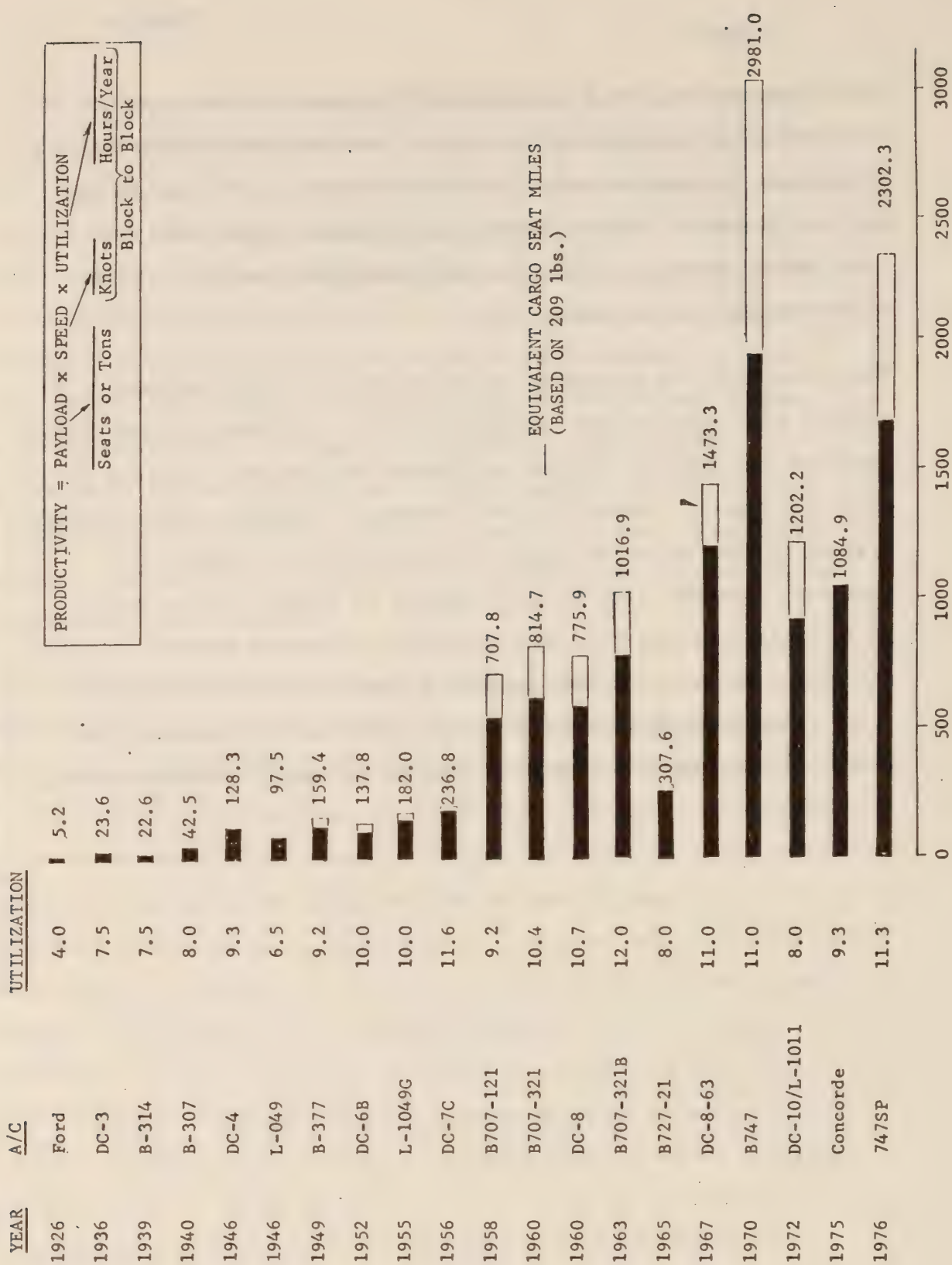
In developing a new airplane, the manufacturer must lay out many dollars for design, aerodynamic, structural and systems analysis, similar testing, tooling, ordering materials and equipment, parts manufacture, sub-assembly then final assembly, flight test and certification. Although orders are accompanied by advance payments, the manufacturer sees no reversal of cash outflow until initial deliveries commence, years after start of the program. If he's very skillful and lucky, he may break even about the same number of years later. With increasing development costs, capital requirements for an entirely new airplane easily can exceed the net worths of both airframe and engine manufacturers. A major mistake, serious delay or accident, or introduction of some unknown factor could mean disaster.

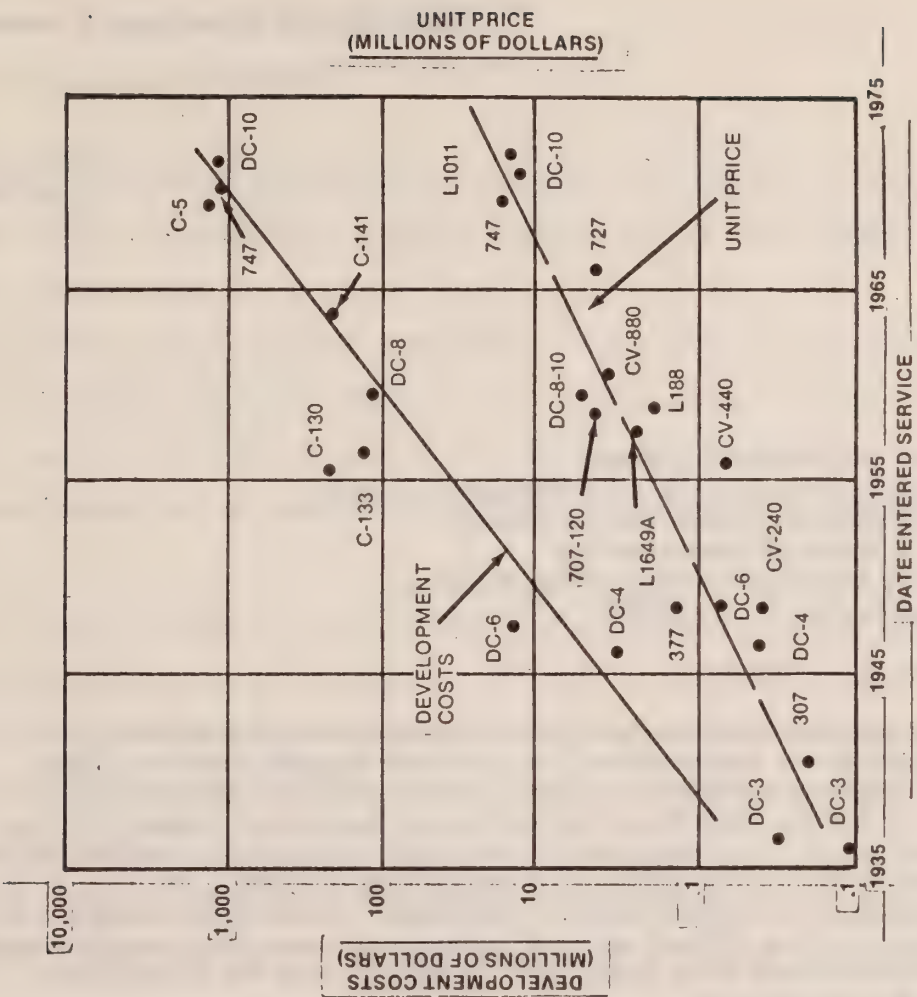
With the present financial state of the airlines, and increasing development costs, it would appear that capital requirements and risk may be becoming too great and potential profits too small to provide sufficient incentive for one manufacturer to go ahead with a new air transport development. If some way could be found to limit the manufacturer's total outflow of cash it should be possible to maintain U.S. leadership in transport airplanes, for the technical leadership is still well in hand, although vulnerable. Perhaps the government could provide financial support through guaranteed low interest loans, or some other means. But, it is considered most important that the government provide support - not control - of the program. There is no more certain way of assuring the mediocrity of future commercial air transports than through the assumption of control of the projects by the government, a

joint corporation, or a committee of "experts". This concept has been tried in the past, with each resultant airplane a failure (examples: the Douglas DC-4E, ATA Specification A-1 - Martin 202 and the US SST). Project control and responsibility must rest with seller and buyer, with the only government control that of airworthiness requirements.

The reason for the preceding review of historical background is to support a contention that we Americans have developed a good system that has resulted in the best airplanes and the best airlines in the world today. Competitive air transport manufacturing/operating systems controlled or strongly influenced by governments or consortia have not been able to measure up competitively, and it is strongly believed they have been more expensive overall to the taxpayers. In other words, we have a good system; it works. If it is going through some rough spots, let's smooth them out, not abandon the system for another that we know hasn't worked as well.

PRODUCTIVITY OF VARIOUS AIRCRAFT





DOUGLAS AIRCRAFT COMPANY

3855 Lakewood Boulevard, Long Beach, California 90846

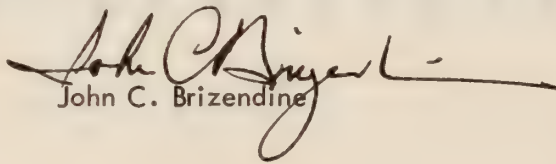
18 May 1976
C1-JCB-265JOHN C. BRIZENDINE
PRESIDENT

Mr. Dale Milford, Chairman
Subcommittee on Aviation & Transportation R&D
Committee on Science and Technology
U.S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, D. C. 20515

Dear Mr. Milford:

The attached paper is submitted in accordance with your request, for review by the Subcommittee. As your letter suggests, there are a host of subjects which must be examined prior to establishing a National Civil Aviation R&D Policy that can sustain the aviation industry into the next century. My paper really is not so all encompassing; however, as the title of the paper suggests, I feel strongly that committee action as advocated by the paper should be instituted. The aviation transportation industry is in a difficult period of existence and some strong medicine must be administered if the patient is to continue to serve the United States as it has in the past.

Sincerely,


John C. Brizendine

JOHN C. BRIZENDINE

Biographical Information

John C. Brizendine has been president of the Douglas Aircraft Company division of McDonnell Douglas Corporation in Long Beach, California since July 17, 1973.

He joined the firm in 1950 and held a succession of increasingly important positions in flight development, engineering, program direction and top management involving the design, production, testing and marketing of McDonnell Douglas commercial and military aircraft.

Mr. Brizendine was manager of the DC-8 and DC-9 jetliner programs and vice president-general manager of the DC-10 tri-jet program. He also was vice president-engineering and executive vice president of the Douglas division and is a member of the McDonnell Douglas board of directors.

Born August 3, 1925, Mr. Brizendine graduated from the University of Kansas with a bachelor of science degree and a master's degree, both in aeronautical engineering. He was a U.S. Navy pilot during World War II.

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ADVANCING TECHNOLOGY IN CIVIL AIR TRANSPORT
 John C. Brizendine, President, Douglas Aircraft Company
 McDonnell Douglas Corporation

SUMMARY

Air transportation remains a true growth industry and a major factor in the world's economy. But disturbing trends are threatening the viability of the airline industry and its supporting manufacturing industry, and therefore threatening U.S. dominance in the world transport market.

Air transportation is vital to the U.S. economy. It provides 85% of the intermediate to long range common carrier movement, and we have no alternative system. It still is a bargain, with U.S. fares up only 35% over the past seven years, compared to rises of 86% in the Consumer Price Index and 100% in rail fares. Industry earnings, however, have not been commensurate with growth. The industry's ability to meet the demands of continuing growth and modernization is dependent upon the confidence of lenders and investors.

Proposed deregulation is a primary threat to this confidence. However, fare options and more liberal charter rules can serve both the airlines and the traveler while avoiding total disruption of the world's best air transportation system and the erosion of lender and investor confidence. We need to remove that threat of deregulation and continue to provide the best service at the lowest cost.

Technology can continue to provide the necessary increases in efficiency and productivity, but not if economic threats block airline modernization. Historically, the civil aircraft industry has transferred technology from DOD programs, with NASA assistance, to civil applications. Recently, however, DOD programs have had primarily tactical applications with little civil fallout, forcing both aircraft and engine manufacturers to seek risk-sharing foreign partners -- with financial backing from their governments. NASA's budget is inadequate to replace the earlier DOD stimulus, and only a small fraction of that budget is applied to aeronautics. While IRAD has value, it offers little incentive to the commercial manufacturer.

To protect and enhance the U.S. industry's position, we recommend:

1. Establishment of a national policy recognizing the national economic value of the U.S. air transport system and the world market dominance by the U.S. civil air transport manufacturers.
2. Creation of a healthy U.S. airline industry through regulatory reform (as opposed to deregulation) and realistic fare management.
3. Recognition of public financial responsibility in the enforcement of environmental regulations, in terms of noise reduction and energy conservation approaches via modernization.
4. A new R&D policy providing direct NASA financial support of R&D leading to civil-applicable technological advancement.
5. Consideration of IRAD coverage for civil projects, with specific tax incentives for civil aerospace R&D.

ADVANCING TECHNOLOGY IN CIVIL AIR TRANSPORT

John C. Brizendine, President, Douglas Aircraft Company
McDonnell Douglas Corporation

Air transportation is a vital element now in the world's economy. The average man, woman, and child in the entire Free World traveled 139 miles by air last year. Driven primarily by American technology and its favorable impact on air fares, an average Free World traffic annual growth rate of 13.5% has been achieved since World War II. Air travel remains one of the true growth industries with worldwide increases some two to three times the rate of overall economic expansion as measured by real Gross National Product. This growth is continuing--witness the rapid following of the recent U.S. economic recovery by traffic increases of near 20% in the U.S. in the last twelve months. Because the U.S. air transport manufacturers have dominated the total Free World market, a substantial American civil transport manufacturing industry has developed providing employment for over 250,000 people. As a leader in that industry, McDonnell Douglas is vitally concerned with the economic health of the airlines--particularly those of the United States. However, some disturbing trends have appeared which threaten the U.S. airline industry and, hence, the supporting U.S. civil transport manufacturing firms.

Scheduled air transportation in the United States today is not just the dominant common carrier transport for all distances beyond those in the daily regime of the automobile; it is essentially the only viable intermediate to long range common carrier system in our country and is carrying over 85% of all passenger traffic at distances over 200 miles. It has no significant competitive system or reasonable alternative. Maintenance of this only viable national passenger transportation system--i.e., air transportation--is not just an arbitrary objective; it is mandatory to the nation's very fabric of existence. A corollary to this fact is the essential need for a strong American civil transport manufacturing industry. This dominance of the air transport system is a consequence of 3 major factors--economic advantages--i.e., a) low fares; b) a service-oriented system that is the envy of the remainder of the world; and c) the fundamental air transport time saving to the traveler. These demonstrated advantages have resulted in the United States air transportation system accounting for nearly half of the total Free World's system in spite of the fact that the U.S. population is only 8% of the Free World's total. The main factor in this success is the relative low cost of such U.S. transportation.

Commercial air transportation is one of the better bargains available to the American public in today's inflation-plagued economy. This is no accident. It is the fundamental results of favorable technology progress coupled with thoughtful governmental regulation of this quasi-utility to guide it via competition to translate the technology-caused cost reductions into fare reductions and competitive service increases to make it useful to the maximum number of people. Figure 1 is a 30-year history of average U.S. domestic airline yields in terms of cents per revenue-paying passenger-mile. One can see that even in terms of current year dollars, airline fares have been held essentially constant except for the most recent year's distortion by inflation aggravated by the near tripling of cost of fuel. If the data in Figure 1 are expressed in constant 1958 dollars, they show that there has actually been a long term decline at 1.78% per year compound rate. (In spite of the problems of 1975, it too was a year of actual yield reductions when measured in constant dollars.) Another way to illustrating this performance is to compare the changes in the airline fares with the U.S. Government Consumer Price Index (CPI). By 1975, airline fares had increased 35% while the CPI had risen 86% over 1958 prices, or almost 2 1/2 times as much. Railroad fares, for example, increased by over 100% in this period in spite of massive Federal economic assistance. One would see a similar favorable air fare comparison if the comparison were made against the cost of a bag of groceries, an automobile, or most other things in our economy. If one moves out of the U.S. economy and compares U.S. air fares with those of other nations, he will also discover that in spite of the high standard of wages in the U.S. and the minimal direct financial support of the U.S. airlines by the U.S. Government, scheduled air fares in the U.S. are the lowest in the Free World. Europe, for example, averages 50-200% higher fares than the U.S.; Japan is some 50% higher. Viewed in the larger context, the fare performance of the U.S. airlines has been outstanding--perhaps too much so.

FIGURE 2

As can be seen by the plots of Figure 2, the U.S. airlines' earnings trend has not been commensurate with the traffic growth. Both their book earnings and their internal cash generation has, in constant dollars, shown a decline while traffic continued to grow (albeit at a somewhat slower rate during the recent economic recession years). In consequence, to

finance the airlines' growth, borrowing has been necessary -- enormous amounts, which have placed the average U.S. airline in a position where it owes twice its net worth to its creditor banks, insurance firms, etc. Hence the U.S. airlines' ability to progress and modernize is largely dependent on the continued confidence of the creditors to provide additional capital. While this general pattern is typical of many growth industries, others have managed to increase their prices and earnings enough to hold debt to more normal industrial ratios of perhaps 40-50% of net worth.

Even though airline fares are now in need of careful reassessment to permit a return to profitability, current proposals for massive and abrupt deregulation may well endanger any progress. This is not to blindly oppose any regulatory change or reform. CAB reform for quicker action on rate proposals and/or fare flexibility for airlines such as a general rule allowing them to set their own fare structure within some reasonable limits (say: plus or minus 30%) would be healthy for the industry as well as the public. The suggested freedom of entry and exit for all scheduled airlines is believed to be counterproductive. The forward thinking of the recent CAB liberalized charter rules which permitted One Stop Inclusive Tour Charters (OTC) to come into effect late last year is beneficial in achieving lower fares and some freedom of entry and exit in a low price market without destroying the service benefits of the scheduled airlines. The proposed Advanced Booking Charter (ABC) should be beneficial to the personal traveler. The public is entitled to expect more creative and imaginative services by the airline which will give them a choice of price and quality of air services. Using European experience as an example, it is reasonable to expect that this more liberal charter authority will have the effect of giving the public that choice. We support the view that a parallel situation will probably occur in the United States and that the principles of more price competition, plus free entry and exit, both achieved through the more liberal charter rules, will establish a pattern which would largely satisfy the objectives of the champions of deregulation while retaining the demonstrated superior service of the scheduled airlines.

If healthy airlines, a viable aircraft industry, and long-term economical fares remain national objectives, two things are strongly recommended: (1) threatened drastic deregulation of the scheduled airlines must be terminated and confidence thus restored within the financial community for the future stability and profitability of the airline

industry and (2) the U.S. must continue the historical pattern of providing better service and low cost fares through the use of more efficient aircraft and systems. Deregulation of scheduled airlines as currently proposed is counterproductive since the very proposal itself has already inadvertently impaired the airlines' key tool to lower costs and fares--modernization by the continuing acquisition of more efficient aircraft. The U.S. airlines' necessity to obtain financing to replace less efficient, noisy, high-fuel-consumption airplanes has been made at least difficult if not impossible by the fears and uncertainty that the deregulation proposals and discussions have created in the financial community. This outside financing, plus internal capital formation from increased profitability, are both necessary for modernization.

The current uncertainties have effectively created a moratorium of progress in the field of energy conservation since new modern fuel-efficient aircraft cannot be purchased. In 1975, the total U.S. airline industry purchased only \$252 million worth of new equipment--the lowest value since 1962 and a value which has caused massive layoffs in the civil transport manufacturing industry. The Douglas Aircraft Company alone in 1975/1976 will reduce employment on civil transports by approximately 10,000 people--a direct consequence of the uncertainties in the airlines.

A convincing argument that continuing advancement of technology does in fact create succeeding generations of aircraft of improved efficiency and productivity can be seen in Figure 3. Here we see the cumulative reduction in the direct operating cost of Douglas commercial transport aircraft since the DC-3. Although these costs of transporting a seat one mile can hardly continue to decrease at these historical rates, we must exert all efforts to prevent any significant reversal in the trend because of cost increases in some of the contributing elements, such as the price of fuel. Continued modernization of airline fleets to take advantage of the already available technology of the modern transport must not be blocked by the uncertainty and threat of deregulation.

In the longer view, the driving force for the continued reduction in airline operating costs is American technology. A strong continuing flow of technology into our commercial transport aircraft will increase the benefits to the traveler, to his earthbound counterpart who seeks a quieter environment, and to the airline managers and stockholders who want tools to fight against the cost pressures such as rising fuel prices. The civil transport aircraft manufacturing industry, like its customer airlines, has been a growth industry perpetually short of capital and totally dependent on the economic health of the airlines--a cyclical health at best. Hence the civil transport manufacturing industry has not had the independent resources to accelerate the technology but has "ridden on the coat tails" of the military aircraft technology funded by the U.S. Government via the Department of Defense and assisted by the

fully dedicated efforts of the National Advisory Committee for Aeronautics (NACA). However the enormously effective impact of many years of research and development accomplished for military aircraft but adapted to the civil transport should be credited as the primary technology driving force. Aircraft cabin pressurization, jet engines, high bypass ratio turbofan engines, aerodynamic and structural refinements are but a few of a host of past civil aviation technology benefits resulting from military Research and Development (R&D). Almost as important as the basic technology development itself was the role of the military in putting that technology into production aircraft when the technical risk (and its consequent financial risk) was intolerable to the civil industry. Each succeeding aircraft development from the all metal airplane to the jet age, and more recently to the new wide-bodied aircraft, has provided significantly more efficient service to more people at lower costs.

Three things have happened which have grave implications on this traditional technology flow. First, the applicability of military aircraft technology to the civil transport has been rapidly declining as the needs of the military -- largely tactically oriented -- have separated from civil requirements. The military aircraft technology budget is concentrated on the supersonic regime and on tactical aircraft of relatively short structural life (compared to civil transports) as typified by the new F-15 and F-16 fighters. Even accepting the concept that the B-1 supersonic bomber has potential technology aid to a future Advanced Supersonic Transport (AST), the technology and requirement differences are large as shown in Figure 4. This same "separation" phenomenon has taken place in the vital aero engine field. Civil transport engines have been typically a further application of military engines. Today, however, we find that General Electric has been driven into a cooperative venture for a new "ten ton" civil engine with the nationalized engine industry of France ("driven", since there was no U.S. Government funding available and the French Government readily funded the major share of the new developments). The other major American engine company, Pratt and Whitney, is similarly teaming up with the nationalized engine industry of the United Kingdom for a competitive engine project. At present, because of the risk and inordinately large funding requirements associated with many of the untested efficiency advancements from new technical innovations, commercial aircraft and engine manufacturers are being forced to work out agreements with foreign companies and governments to share the risk and provide funds for such improvements. The new subsonic ten-ton engines by GE (CFM-56) and P&W (JT-10D) are leading examples. Such risk-sharing ventures with foreign companies and governments would

not be necessary if the United States Government R&D policy specifically supported civil transport aviation to an extent consistent with the importance of economical air travel and the importance to our nation of retaining a competitive aircraft industry.

Second, the impact of the space age and the national objective of a Man on the Moon swept NACA into the space dominated National Aeronautic and Space Agency (NASA). While the aeronautics portion of NASA's budget has been steadily increasing as a fraction of the total NASA budget since the low of less than 2% in the mid-1960's, it is only some 8% of the total NASA budget today and a subjective evaluation by my company shows that three percentage points or less of that 8% are truly applicable to the civil transport field, particularly as it applies to the goals of the next five years. NASA's work is largely oriented to long term goals and, as such, is not a substitute for the progressively less applicable military effort. The work that NASA does do is valuable. Some recent examples of NASA research which will pay off in the future with lower airline costs and thus transferred back to the people via lower fares, are the supercritical airfoil, composite structures and winglets. However, in any event, the current \$200 million NASA aeronautics budget could not make up for the fact that the multi-billion dollar military aircraft research and development budget is becoming less applicable to the civil transport problem.

Third, the principle of Independent Research and Development (IRAD) and the consequent accounting treatment of such company expenditures as benefits to national interests has always been well recognized in the military aircraft sphere. In effect, this concept has allowed aircraft companies to charge independently directed research, equivalent in value to 2-3% of the annual sales of the company, against the cost structure of military contracts as an allowable item recoverable in the price of the military contract. This accounting allowance recognized the value of diversified approaches to critical national technologies. However, this is of no aid to the civil transport manufacturing company who must fund these equivalent efforts from his profits. Civil aviation is a major economic asset to our nation. In the days of troubles on our nation's balance of trade, the Washington quip was, "Thank God for aerospace and the farmer," these being the two major American helpers to a positive trade balance. Civil aerospace is a dominant element, as shown in Figure 5. The Federal Government takes some 23% in taxes for each dollar of increased economic activity from these favorable exports. Using a conservatively-assumed economic multiplier of "2" for the imported dollars, just this civil aerospace export business creates some \$3 billion annually in added Federal tax revenues. It should not be necessary to further point out the national importance of supporting civil transport technology.

What are the recommendations in view of these developments? The following are my summary suggestions:

1. Establish a national transportation policy recognizing the national economic, social and strategic value of air transportation and the unique U.S. civil transport manufacturing industry with its world market dominance.
2. Create a fiscally healthy U.S. airline industry.
 - a. Recognize the earnings need to create capital for more efficient equipment.
 - b. Sponsor regulatory reform -- not deregulation.
 - i. Zone of reasonableness concept to allow airline freedom to set fares independently.
 - ii. Increased charter freedom for both scheduled and non-scheduled airlines.
 - c. Automatic fuel cost increase flow-through to fares (as is the case in utility regulation).
3. Recognize general public benefit and consequent financial responsibility in environmental regulations enforcement on airlines.
 - a. Financial aid should be supplied for equipment modification or replacement made mandatory by public law.
 - i. Recognize that such expenditures are not a responsibility solely of the airline industry or its passengers.
 - ii. Provide low interest modernization loans a la the Conrail/Northeast corridor which approximate \$3.8 billion.
 - iii. Allow special investment tax treatment (negative income tax) recognizing the fact that the purpose of investment tax credits is defeated if the airline is not profitable.
 - b. Encourage modernization replacement rather than short term modification.

For example, modification for noise reduction is marginal in effectivity and produces no benefits in economies or fuel conservation to the airlines.

4. Increase the emphasis on Government-sponsored aeronautical R&D that has specific application to civil transports. The NASA budget should be increased specifically for this purpose with the proviso that at least 75% of the increase should flow to industry research contracts. Experimental research and development to build and flight test on current modern turbofan transports new ideas which hold promise of improvements in commercial airplane efficiency should be funded via such NASA research contracts. This would not replace the long term further future work of NASA but would be an addition pointed toward speeding high risk technologies into application. NASA past funded work on large scale composite structures such as the composite rudder for the DC-10 airplane is an excellent example of this technique.

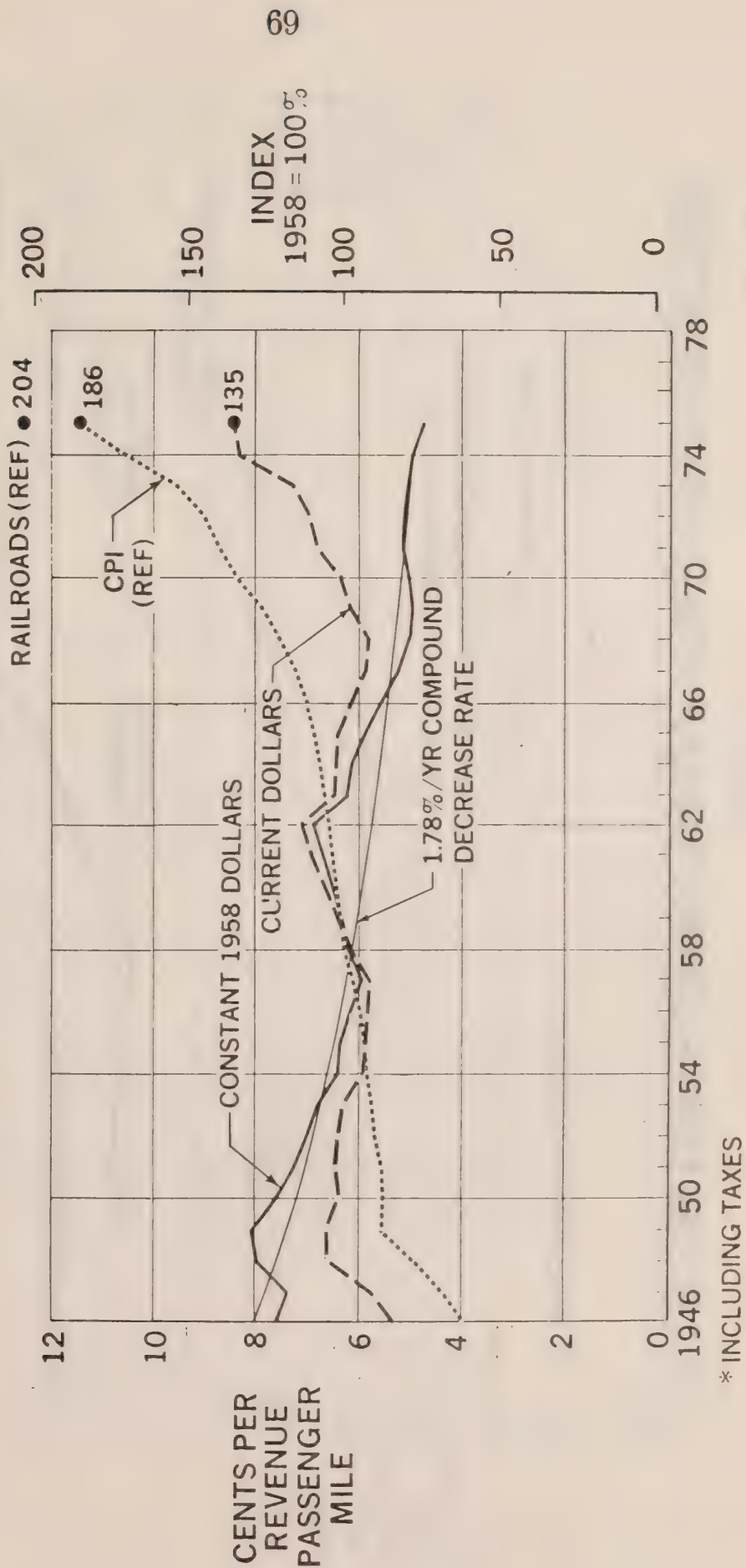
In addition, future high cost, redundant, specialized test facilities such as very high Reynolds number wind tunnels applicable to large transport airplanes should not be created at each manufacturer. Instead, a central NASA administered test facility (with industry participation in the design and management) should be used to economically satisfy such needs.

5. Consideration should be given to IRAD coverage for non-defense projects of national benefit with serious consideration given to specific tax incentives on R&D for aerospace companies which have predominantly commercial sales.

The preceding are broad concepts which cannot be detailed in a brief paper. Should these ideas be judged worthy of expansion, I would be happy to meet with you myself or have my appropriate executives expand these concepts for you in discussion. I thank you for the opportunity to present the thoughts contained in this paper.

FIGURE 1.

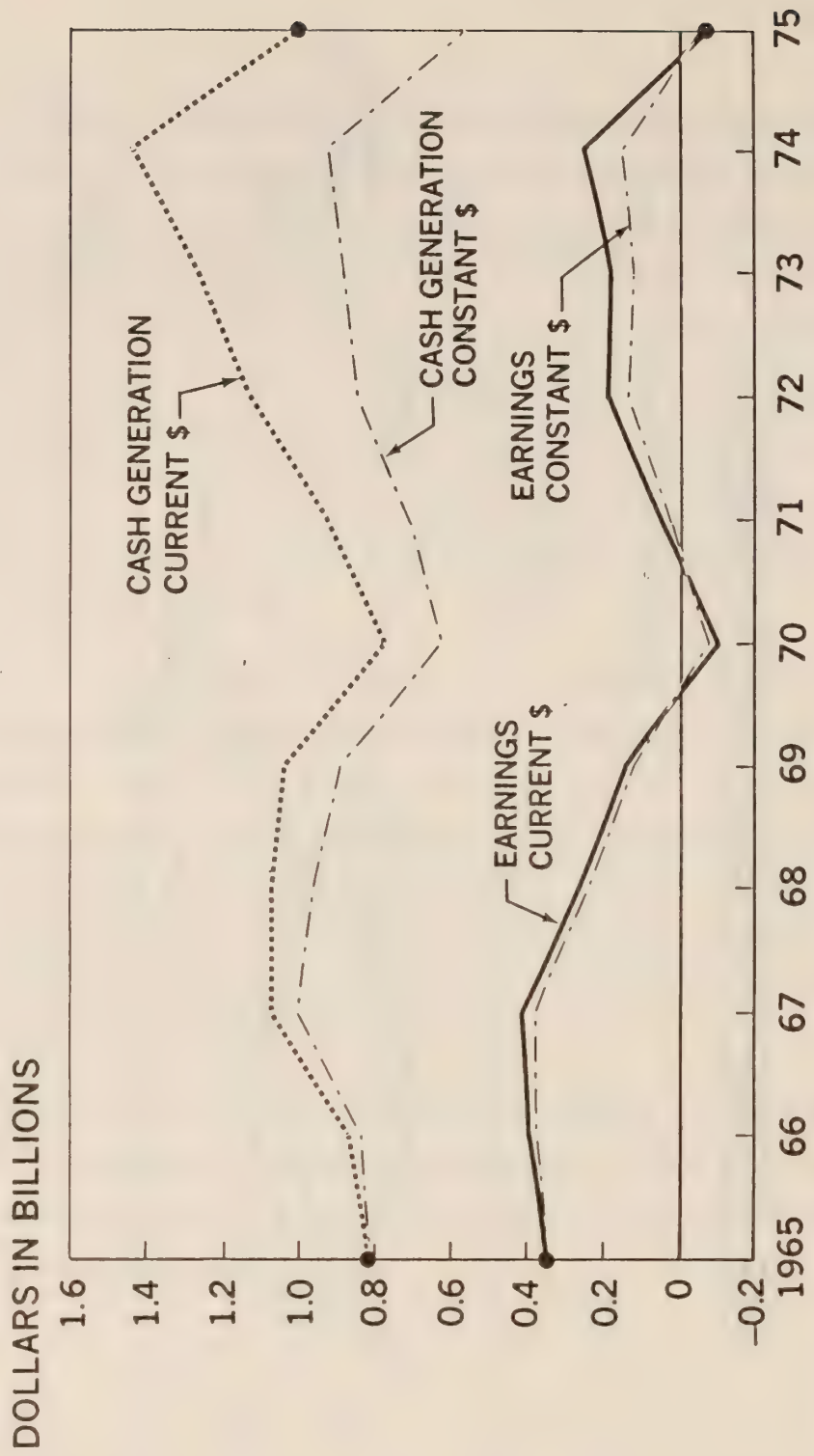
U.S. DOMESTIC AIRLINES FARES*



* INCLUDING TAXES

FIGURE 2.

U.S. TRUNK EARNINGS AND CASH GENERATION

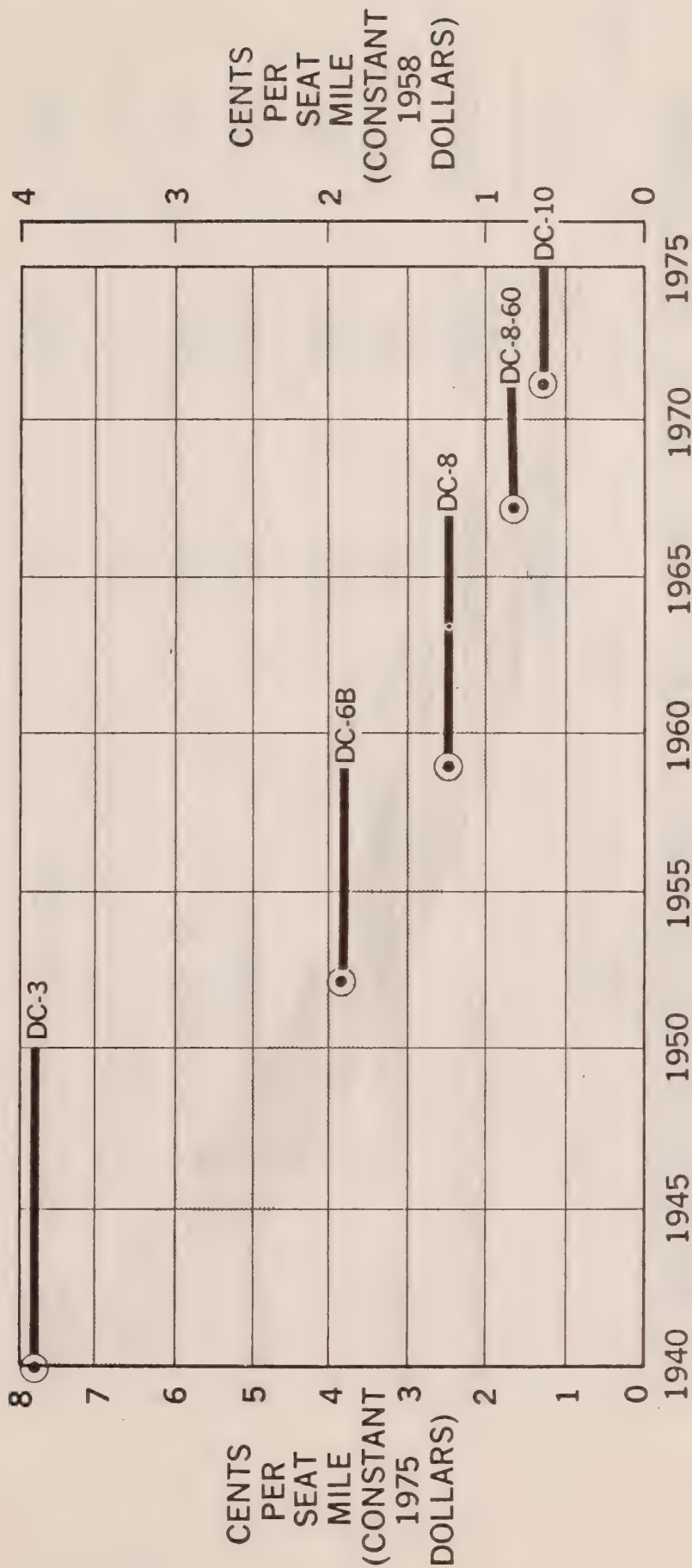


* ESTIMATE

PR6-PL-30017

FIGURE 3.

DIRECT OPERATING COST



CENTS
PER
SEAT
MILE
(CONSTANT
1975
DOLLARS)

CENTS
PER
SEAT
MILE
(CONSTANT
1958
DOLLARS)

FIGURE 4.

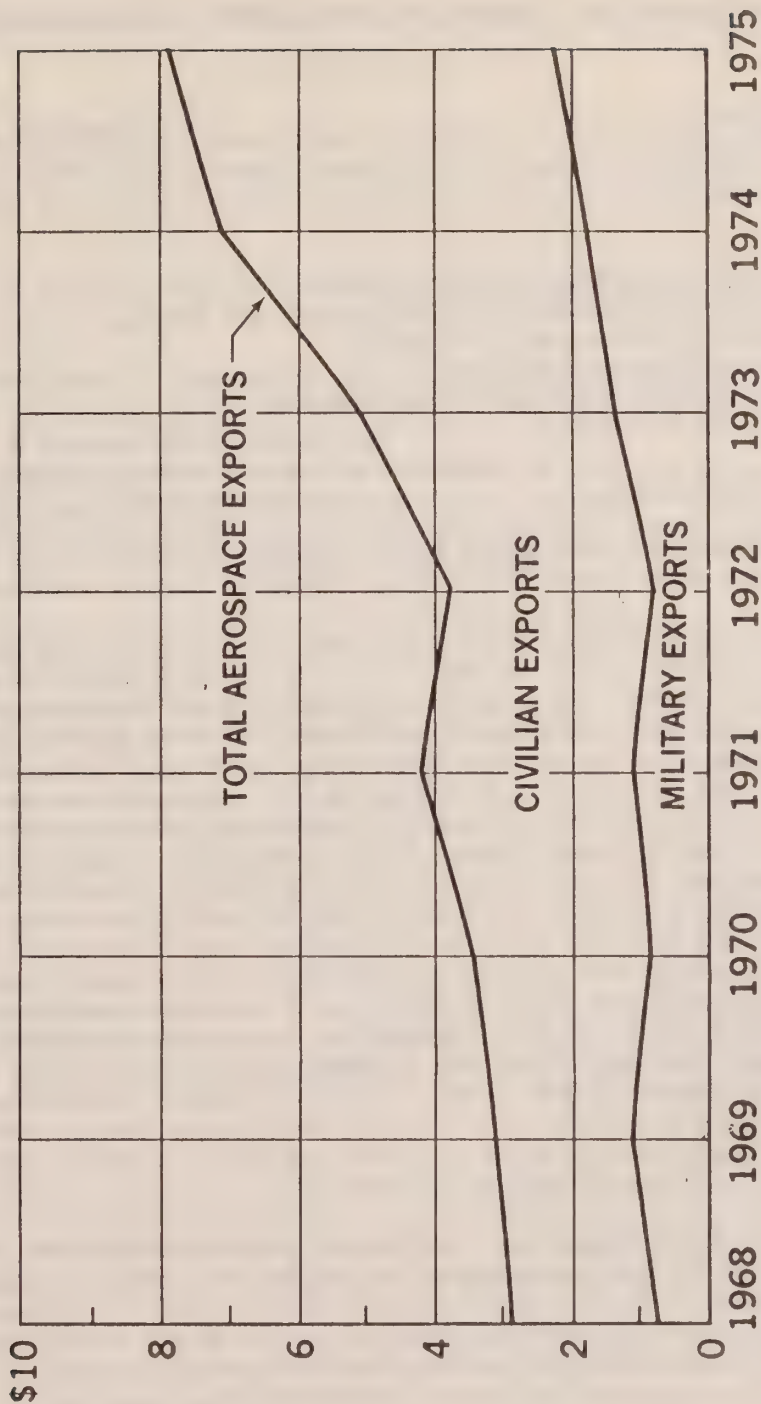
DIVERGENCE OF MILITARY AND CIVIL DESIGNS

	B-1	F-15	AST
OPERATING LIFE (HR)	13,500	8,000	50,000
HOURS AT TEMPERATURE (AERO HEAT)	390	32	35,000
(°F)	265	255	250
MATERIALS % TITANIUM	21	26	63
% ALUMINUM	41	35	27
% STEEL	15	4	9
DESIGN LIMIT LOAD FACTOR	2.0	7.3	2.50

FIGURE 5.

AEROSPACE EXPORTS

(BILLIONS OF DOLLARS)



SOURCE: DEPARTMENT OF COMMERCE
E: ESTIMATE

CALIFORNIA INSTITUTE OF TECHNOLOGY

PASADENA, CALIFORNIA 91125

DIVISION OF ENGINEERING
AND APPLIED SCIENCE

May 13, 1976

The Honorable Dale Milford, Chairman
 Subcommittee on Aviation and Transportation R&D
 Committee on Science and Technology
 U.S. House of Representatives
 Suite 2321 - Rayburn House Office Building
 Washington, D. C. 20515

Testimony of Dr. Robert H. Cannon, Jr.
 Chairman, Division of Engineering and Applied Science
 California Institute of Technology

Dear Mr. Chairman:

I appreciate very much being invited to contribute to the hearings on the Future of Aviation which your subcommittee is holding this month.

In June of 1974, just before I left my position as Assistant Secretary of Transportation, I was invited to testify before Senator Moss' committee in a similar context. At that time I presented my views on some of the research and development programs which I believed to be critical to a future aviation transportation system that would continue to serve our country in the years ahead in the most stimulating and vigorous way economically, while at the same time providing absolute protection for our environment and the maximum safety to human life. In that testimony I included discussion of the continuing evolution of an effective air traffic control system so that never again would we encounter a crisis as we did in 1969, so that we would always be a step ahead of any growth in air traffic, providing, with never a hitch, the most time-efficient and energy-efficient movement of commercial air traffic with the highest level of safety. As you know well, staying that step ahead requires an R and D program that sees a decade ahead, into both potential requirements and the new technological opportunities to provide better performance at less cost. With full national deployment of the ARTS III Air Traffic Control System the FAA has now gotten on top of this problem. The long-range R and D program FAA has laid out is designed to keep us on top. It must not be allowed to slacken.

In my 1974 testimony I discussed also new technical possibilities for improving the fuel economy of transport aircraft, including more precise navigation, and the use of new automatic control techniques to provide better flying stability with less structure (and hence less drag). I have recently had opportunity to review the NASA programs in pursuit of these opportunities, and note that they are proceeding vigorously.

Finally, in my 1974 testimony to Senator Moss, I pointed out the probable requirement for cleaner engines in both subsonic and supersonic aircraft in order to protect the earth's ozone layer which shields us from damaging ultraviolet radiation. I noted then that the report from a major technological assessment of that question would be forthcoming, and would spell out what measures will be required to provide full protection.

May 13, 1976

The report of which I spoke was published in the spring of 1975, and I should like to use this present opportunity to focus particularly upon its results and the impact they will have for the future of commercial aviation.

The report has the official title, Report of Findings of the Climatic Impact Assessment Program. Briefly, it supports the following conclusions:

- (1) Preservation of our ozone layer is imperative in order to shield us from biologically harmful ultraviolet radiation from the sun.
- (2) Any really large-scale commercial operations in the stratosphere (supersonic or subsonic) anywhere in the world would have to be under strict engine-cleanliness standards to avoid significant world-wide reduction in the ozone layer.
- (3) Clean engine development is feasible, technically and economically, but will require a lead time of at least ten years.

It is item (3) above which gives special urgency to this matter. For, while current levels of operation reduce stratospheric ozone by an amount which is imperceptible, only by strictly requiring future engines to be substantially cleaner can any future, much larger fleets be prevented from reducing ozone by an unacceptable degree. It is urgent to act now, because the development of cleaner engines will take some 10 to 15 years to achieve. Thus, clean-engine standards and the development of clean engines to meet them, must anticipate any possible fleet growth by at least a decade.

What the Climatic Impact Assessment Program (CIAP) makes possible is for us to anticipate and totally avoid what could be a serious problem, and to do so at minimum cost simply by taking prompt, deliberate, positive actions--both in Research and Development and in the area of international standards setting.

Prior to the CIAP, the concerns raised by a number of scientists about a number of ways that high altitude flight might affect the environment were on such uncertain ground that it was impossible to know where, in the range from truly serious to entirely negligible, each such concern might lie. It was simply not possible to lay out a prudent course of action.

In organizing the CIAP, I made sure of four things: first that the finest scientific specialists in the world were thoroughly involved in the program and in the process of organizing and presenting its conclusions; second, that all aspects of the program were conducted in the most open possible way; third, that an independent assessment of the results was made by a special committee of the National Academy of Sciences and the National Academy of Engineering; and fourth, that the full results were made available to the Congress promptly.

The CIAP was perhaps the most comprehensive technological assessment that has been carried out to date. During the course of this

intensive program, the uncertainties about what the consequences of high altitude flight might be were reduced from factors of the order of 100 down to factors of the order of 3 to 10--reduced to where conclusions can be drawn and prudent courses of action can be specified.

In particular, the CIAP determined that, of the numerous possible adverse environmental effects of stratospheric flight that were postulated in 1970 and 1971, two will require specific preventive measures if a very much larger volume of high-altitude operations occurs (by either supersonic or subsonic aircraft flying anywhere in the world):

First, engines having lower levels of nitrogen oxide emissions will have to be required. This will be necessary to avoid reduction of stratospheric ozone which limits the amount of biologically harmful ultraviolet radiation that reaches the earth.

Second, jet fuels having a sulfur content smaller than that in current jet fuels will have to be required. This is necessary to avoid formation of sulfate particulates in the stratosphere which could alter the heat balance and hence temperature and rainfall.

The second requirement--for low-sulfur jet fuel--appears relatively easy to meet. Apparently only a few years' lead time will be needed to achieve almost any sulfur-content standard that may be set.

But to meet the first requirement--for low-NO_x engines--10 or 15 years of engine development will be needed.

To insure that the environment is fully protected, whatever the growth and development of stratospheric flight may be in coming years, the Executive Summary of the CIAP Report of Findings recommends the following courses of action:

Develop, on an urgent basis, a proper program of international regulation of aircraft emissions and fuel characteristics for whatever stratospheric flight operations may evolve in the future.

Accelerate combustion research and engine development programs needed to make stratospheric flight possible with specified nitrogen oxide emission standards.

Use low-sulfur fuels. Study the implications of utilizing low-sulfur content aviation fuels for stratospheric flight.

Develop a global monitoring system to ensure that environmental protection is being achieved. Continue research (drawing on the monitored data) to reduce the uncertainties in the present knowledge of the stratosphere and improve the methods for estimating climatic change and the biologic consequences.

May 13, 1976

To these recommendations the independent report of the National Academies of Sciences and Engineering adds one more which I wish here also to strongly endorse: "We recommend that biological and medical studies of the effects of changes in ultraviolet radiation upon living organisms be increased. In particular, we recommend that studies of skin cancer be accelerated to obtain better quantitative understanding of the cause of the disease."

Since the publication of the CIAP Report of Findings (and indeed beginning well before that publication) both the National Aeronautics and Space Administration and the Federal Aviation Administration have taken important steps to implement the CIAP recommendations.

The NASA has received good 1976 budget support from the Congress to begin the ongoing atmospheric measurements that will contribute to both the monitoring base and the further reduction of uncertainty. This support must be sustained to achieve the objective of protective early warning.

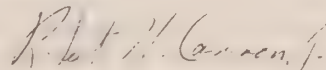
The NASA has also begun astute research on clean engines. This can help the FAA structure future standards, which in turn can give engine manufacturers fair warning, with targets they can expect, and confidence in the fundamental aspects of the technology.

The Federal Aviation Administration--with its new High Altitude Protection Program (HAPP)--has assumed responsibility for developing standards, and has begun the process of interaction with the aviation community, American and international, that must precede regulatory action. This activity must be encouraged relentlessly by The Congress.

Mankind has seldom come to a potential problem of such inherently global a nature, or been blessed with such a clear early understanding of how to avoid it. To seize this opportunity--to proceed promptly and deliberately to provide effective protection, without the trauma and waste of a crash program, could set a precedent of considerable generic value for the future.

I enclose a few pages of technical background on this issue which the Subcommittee may find helpful. (A full report is, of course, given by the CIAP Report of Findings.)

Sincerely,



Robert H. Cannon, Jr.
Chairman, Division of
Engineering & Applied Science
California Institute of Technology

RHC/ihl

Some Background on
Preventing Environmental Impact from Stratospheric Flight

During the discussion of the supersonic transport (SST) project in 1970, the question was raised (Wilson et al., 1970; Johnston, 1971) whether impurities from flights of aircraft high in the stratosphere could alter the proportions of atmospheric constituents with harmful results to the earth's environment. The question is important because, while they make up only a tiny fraction of the atmosphere, the constituents in their natural proportions control the balance of life-giving heat while blocking lethal radiation that otherwise would reach the earth's surface.

Flight in the stratosphere (typically above 12 kilometers or 39,000 feet) is of concern, while flight in the troposphere below is not. The reason is that, through turbulence, storms, and rainfall, the troposphere cleanses itself of impurities in a matter of days or weeks, but the stratosphere is virtually stagnant in its vertical dimension and does not cleanse itself so rapidly. Impurities remain in the mid-stratosphere for as long as three years (so that there is always a three-year accumulation of past contaminants). Moreover, their dispersion, horizontally, is worldwide and comparatively rapid, so that stratospheric fleets of any nation, flying anywhere, produce similar effects everywhere in the hemisphere (northern or southern) in which they fly. High-altitude commerce over Europe contaminates the sky over the United States, and vice versa.

In 1970, large uncertainties existed in our quantitative knowledge of the atmosphere's constituents, of its dynamic and chemical behavior, and of the climatic and biological processes affected by the atmosphere. Thus, at that time, there was no valid scientific basis for judging where, in the range from entirely negligible to truly significant, the conjectured effects of stratospheric flight might fall. There was simply not enough knowledge from which to draw the needed scientific conclusions.

During the congressional debate in July 1970, legislation introduced by Senator H. M. Jackson directed the Department of Transportation to mount a federal scientific program to obtain the new knowledge needed to judge how serious the conjectured effects might be, and to report its results to the Congress by the end of calendar year 1974. This report of findings describes the results of the ensuing program.

The Department's Climatic Impact Assessment Program (CIAP) has drawn on nine other U.S. federal departments and agencies and seven foreign ones. It has also drawn on the individual talents of some 1000 investigators at numerous universities and other organizations in the United States and abroad. It has necessarily encompassed a wide range of science and technology.

A special committee of the National Academy of Sciences and the National Academy of Engineering was organized to review the work of CIAP and to form an independent judgment of the results on which the Academies have issued a special, independent report (Reference 4).

The CIAP has yielded a harvest of new scientific data, and has progressed considerably in drawing the data together into a better understanding of the cause-effect relations between aircraft effluents in the stratosphere and environmental impact. Serious uncertainties still exist, but their magnitude has been reduced substantially so that useful conclusions are now possible. Briefly, they indicate that while present aircraft operations in the stratosphere do not threaten the environment, in the future cleaner engines and cleaner fuels will need to be required to insure that no future larger-scale operations ever do. Early warning by responsible scientists and prompt, careful assessment have provided the time to act deliberately to insure full environmental protection.

In particular, aircraft engines, meeting reduced nitrous oxide (NO_x) emission standards, must be required in order to prevent reduction in the stratospheric ozone that blocks the sun's ultraviolet radiation at the wavelengths associated with sunburn, nonfatal skin cancer, and other biological effects.

The CIAP was completed on time, and its Report of Findings was delivered to the Congress on schedule (Reference 5). But in a larger sense, the CIAP was only a first step in the continuing vigilance we must exercise. Specifically:

The uncertainties are still large and must be reduced by continuing atmospheric and biological research.

The stratosphere must be monitored carefully from now on to assure that our protective measures are doing their job.

The engine development must be carried out to provide future aircraft with clean engines.

Finally, international regulations must be developed in an orderly fashion to provide for protective measures as they are needed.

There is time to do each of these deliberately without the wasteful costs of a crash program. But there is no time to waste. Action must be prompt and sure, starting at once.

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STATEMENT FOR THE RECORD
ON
THE FUTURE OF AVIATION
SUBMITTED BY
RICHARD E. COHEN
BUREAU OF INTERNATIONAL COMMERCE
U.S. DEPARTMENT OF COMMERCE
TO THE
SUBCOMMITTEE ON AVIATION AND TRANSPORTATION R&D
COMMITTEE ON SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

MAY 14, 1976

THE CHANGING ENVIRONMENT FOR U.S. INTERNATIONAL AEROSPACE
BUSINESS

SUMMARY:

The United States enjoys a well-recognized position of world leadership in aerospace manufacturing, paced by the success in the world market of U.S.-built civil and military aircraft. More than 80 percent of the free-world commercial airline aircraft are of U.S. manufacture. The U.S. exports over 2-1/2 times as many general aviation aircraft as the rest of the world. However, this image of world technological leadership earned by the United States aerospace industry during the 1960's is being eroded in the 1970's due to a lack of new programs resulting from the strain on investment resources. This is in contrast with the continuing achievements of European consortiums, and the efforts of Canada and Japan. Despite strongly emerging foreign competition, U.S. aerospace exports have continued to be a significantly positive factor in international trade, (Table 1). Aerospace exports have exceeded \$1 billion annually since 1957, have reached over

\$7 billion for each of the past three years, and in 1975, reached a record \$7.8 billion representing 25 percent of the industry's total sales and accounting for more than 7 percent of all exports of U.S. products.

According to the U.S. Industrial Outlook 1976, an annual publication of the Bureau of Domestic Commerce, U.S. Department of Commerce, aerospace exports in 1976 are expected to reach over \$7.6 billion, a 4 percent decrease from the all time high in 1975. More than 40 percent of the aircraft shipments in 1976 probably will be for the export market. Aerospace exports in 1976 will account for more than 200,000 full-time jobs. Imports of aerospace products are estimated at \$419 million for 1976, resulting in a positive trade balance for the year estimated at more than \$7.2 billion. The U.S. aerospace industry continues to be the largest single manufacturing contributor to the nation's trade surplus.

For the first time in recent history, Europeans significantly challenge U.S. dominance of the Free World aerospace market. With strong support from their national governments, multinational European aerospace manufacturers are attacking product and market niches now lacking U.S. action. As a result, by 1980, Europe could take possibly \$1-2 billion annually away from the U.S. share of the Free World aerospace market. Beyond 1980, this loss of market share, and therefore exports by U.S. companies, could run much higher. In the face of a determined

drive by European governments to strengthen their aerospace industries, U.S. industry will have to work hard to minimize this loss.

Historically, the U.S. aerospace industry has been extremely successful in the international arena by almost any measure. For example, the U.S. share of Free World export markets in aircraft, engines, and parts has been well over 50% for the last decade, according to international-sourced statistics published by the U.S. Government on market shares in aircraft, engines, and parts markets.

This performance reflects many U.S. strengths, especially the expanding U.S. domestic market for high-quality aerospace products that could also be exported and major government expenditures for aerospace-related R&D. U.S. companies also used aggressive marketing and logistics support for customers at a time when foreign competition was suffering from small national markets and fragmented production. These strengths have supported U.S. dominance into the 1970's. However, this situation can be expected to change before the end of this decade.

The United States' major airframe and engine manufacturers' financial resources are committed to their investments in the new wide-bodied jet airliners. They are in the unfortunate position of being without sufficient venture capital to undertake any new major risk programs in order to meet new competitive

foreign programs. Accordingly, U.S. aerospace companies are looking to government-supported foreign aerospace industries for financial assistance in new development and production programs. These joint programs are not predicated on an interest in exporting only U.S. technology, but rather in an attempt to maintain the firms' present share of the world market.

The U.S. Government provides no direct support to commercial aircraft development, production and sales ventures except through the application of military and National Aeronautics and Space Administration research and development and Export-Import Bank loans and guarantees. In Europe, commercial aircraft usually are fully financed with venture capital provided by the various governments alone, or in concert. The Japanese, through Zaibatsu--a coalition of manufacturers, banks, trading companies and government--provide full or partial support to manufacturing, sales, and support of commercial aircraft. Canada's aerospace industry has been subsidized by the government for a number of years, initially to preserve it as part of a mobilization base, but lately in recognition of its significant contribution to the country's balance of trade.

In addition to the competition from foreign-developed and produced commercial transport aircraft, foreign governments are actively increasing competition in military aerospace programs. Some have negotiated agreements providing for rising military

sales to Latin America and African countries where U.S. Government policies have restricted sales of U.S. equipment. European military and civilian helicopters are increasingly displacing U.S. helicopters in world use.

The Continental European countries and Great Britain--comprising the major U.S. aerospace export markets--are moving toward meeting their vast military and civilian aerospace equipment requirements by combining their industries into consortiums. Their goal is principally to end reliance on U.S. aerospace products, although this approach has a reported 20 percent cost disadvantage. Only items beyond the financial or technological development ability of the consortium countries are being procured from outside sources. These outside buys are on a highly competitive basis and frequently require mandatory production licensing arrangements.

In the past, foreign aerospace suppliers have not been able to achieve an overall competitive advantage, despite initial market penetrations, because U.S. suppliers have been able to offer a full line of economical, efficient, and attractively priced equipment in a sufficient range of compatible models to meet potential users' total requirements. They have been able to do this even when they have entered the market later than the foreign competition. Due to the lack of available new venture capital and the increased competitiveness of foreign-government supported industries and consortiums, the U.S. aerospace

industry cannot rely on continuance of the advantages enjoyed in the past.

The major policies supporting the development of aerospace capabilities within the five countries with the highest developed aerospace industries--France, West Germany, United Kingdom, Japan, and Canada--are designed to achieve improved competitiveness in the world market place as follows:

- o Government support of consortia team efforts to design, sell, support and finance families of commercial and military aircraft.
- o Develop management and manufacturing capabilities in order to achieve independent high technology capabilities. United States and/or foreign technology and know-how is imported through multinational development programs, licensing, and requirements for offset development and production to balance major procurements of foreign (U.S.) equipment by national agencies.
- o Government initiatives in rationalization or nationalization of aerospace industries in order to reduce uneconomic domestic competition, pool resources and development financing, standardize equipment for government/industry foreign sales efforts and increase productivity.
- o Government long-term budget planning and funding allocation for specific aerospace programs with expected export potential,

recognizing that over the long-haul advanced-technology industries such as aerospace hold the key to future industrial expansion.

MAJOR PROBLEMS - U.S. AEROSPACE INDUSTRY:

The financial condition of the U.S. aerospace industry constrains its ability to continue major aircraft developments and to provide the technology required to develop new markets and to maintain its position against foreign competition. The research, development, and initiation of production for modern transport aircraft require a peak commitment of more than \$1 billion, several times the net worth of most U.S. airframe manufacturers. Engine manufacturers must commit more than \$500 million to undertake a new engine production program. The working capital risk requirements of the aerospace manufacturing and air transport industries inhibit the continued investment in R&D programs. In addition, civil sales are increasingly more important in total sales, thereby providing a lesser share of independent research and development to be carried by military contracts.

o Direct Government Funding, with or without recoupment, for development and production of aerospace equipment would ease the severe cash flow problems traditional in the industry and tend to reduce the cost of the equipment. This approach does raise the problem of Government judgment replacing market values in the selection of programs. It also negates

the force of competition in the traditional development of better equipment at lower cost. Procedures can be developed to counter these problems. Government guaranteed loans for development and production raise the same issues and do not provide the same relief from cash flow problems. The establishment of a government-supported National Technological Development Bank, providing loans at moderate interest rates would be an alternate method of developing programs which have national benefits but too high a risk for commercial financial sources.

- o Tax incentives could stimulate the industry to increase R&D, resulting in increased technical employment, increased productivity, development of new markets, and increased investment and general employment. The problem is to first improve the income position of the firms through decreased costs of operation.
- o The application of the federal antitrust laws is uncertain in the areas of joint research and development. These laws need to be reviewed in order to define revisions for the promotion of technological growth, especially against joint ventures of foreign competitors.
- o The continued availability of an investment tax credit and the review and modification of other Internal Revenue regulations, including accelerated depreciation allowances might

alleviate current cash flow problems and capital investment and thereby facilitate domestic sales of aerospace equipment.

o Stimulation of U.S. exports in the market environment of large-scale foreign competition by nationalized, or quasi-nationalized firms and consorita requires that favorable financing be available for civil and military equipment. These export financing requirements include continued Export-Import Bank aircraft financing, including increasing lending authority, extending repayment time, and providing for progress payments between order and delivery.

TECHNOLOGY:

The U.S. aerospace industry is an advanced technology industry, it is characterized by its emphasis on research and development as an integral part of systems fabrication, rather than only as the first stage in production of an item. The aerospace industry has had to develop capabilities and resources to keep up with a constantly accelerating technological advance and the radically new techniques required to contend with problems of infinite complexity. Much of the industry's output is in the form of technological inventions and innovations stemming from intensive research and development. The industry's complex products are characterized by high unit-value, precision performance, and reliability.

Defense and space goals have dictated the bulk of R&D demand, but R&D in aerospace has also created a number of spillover

-10-

effects that have influenced technology in metallurgy, computers, electronics, ceramics, fuels, and power equipment.

The following discussion is extracted from the Report of Working Group 8 (Air Transport Environment), Section 3 - Aeronautical Technology Projections, International Aviation Policy Review, which addresses those advances which are likely to have a significant influence on the aircraft expected to be operational through 1985 - 1990, (Table 2).

In view of the large recent investments in widebody transports, the slowdown in demand growth, the rising fuel costs, and worldwide economic problems, the character of the long-haul transport aircraft fleet is not expected to change dramatically over the next decade. Much of the commercial transport demand will be met at least through 1980, and probably through 1985, by additional production of aircraft currently in service and by derivatives of these aircraft. The derivatives and growth versions will incorporate some new technology, but to a limited degree consistent with the objective of avoiding a new development cost. One possible exception is the Concorde, to be introduced in 1976, which could, when fully operational, capture most or all of the first-class trans-Atlantic traffic and some fraction of the business-travel coach traffic. It is conceivable that this could eventually lead to a U.S. SST; if so, however, operational introduction would not be expected during the time period being considered. There is also a possibility

-11-

that competition, or an upturn in demand and the financial outlook, will stimulate development of a new subsonic transport (e.g., "7X7", "DC-X" or "L-10XX").

Technology likely to be incorporated in the modifications or derivative aircraft sold during the next decade will include engine and aircraft component improvements directed at reduced fuel consumption, reduced noise, reduced emissions, and increased propulsive and aerodynamic efficiency. These improvements could appear on aircraft ready for service by 1980. More effective improvements based on R&D currently ready or nearing readiness (e.g., supercritical wing, high aspect ratio, composite structures, quiet engines, clean combustors, active controls) could be incorporated in new aircraft ready for operation by 1985, should conditions warrant their development.

The primary benefits associated with these improvements can be summarized briefly as follows:

Fuel savings

Modified or derivative aircraft which could be operational by 1980 should exhibit fuel savings on the order of 10 percent, with corresponding cost savings dependent on fuel prices.

All-new production aircraft which could be operational by 1985 would be expected to yield savings closer to 30 percent. If the development of new aircraft is delayed an additional 5 years, savings as high as 50 percent appear technically feasible.

Emission improvement

The concerns relative to stratospheric pollution expressed, for example, in DOT's "CIAP" report primarily concern NO_x emissions. Minor combustor modifications based on technological advances made within the next 4 to 7 years could reduce the NO_x emission index by approximately 30%. New engines which could be developed and certificated by 1985 could incorporate major combustor redesigns which would reduce NO_x emission indices by as much as 75% below those of current production engines. It appears that still lower NO_x emission levels are at least theoretically possible, but this further improvement would not be expected during the time period under consideration.

Noise reduction

It appears that the refanned JT8D engine could reduce the noise of the narrow-bodied transports (727, 737, DC9) to below FAR 36 levels; however, no decision has been made to retrofit any of the airline fleets with these engines. The cost of retrofit is the prime deterrent. It is most probable, however, that an improved JT8D series incorporating the refanned engine technology will be produced and installed starting in 1978 in new production stretched versions of 727 and possibly DC-9 aircraft. These growth versions, since they will utilize increased thrust, will not realize the full noise-reduction benefits of the new fan; they will, however, meet the FAR-36 limits and will be significantly quieter than the current narrow-bodied aircraft.

FAR-36 (and ICAO Annex 16) regulations are being met or bettered by the wide-bodied transports currently in production. Growth versions of these aircraft will require increased thrust and possibly longer climbouts. They may therefore be somewhat noisier than current models, but still must meet the FAR-36 noise levels.

Apart from the airframe and engine advances, some significant changes are anticipated in guidance, navigation, and traffic control, beginning within the next 2 years and continuing throughout the next decade. Major improvements to the ATC system are likely to result from ATC automation, advanced metering and sequencing, better surveillance, and airport surface traffic control improvements. The major technology developments expected in these areas are:

(a) Adoption of an updated landing guidance system, replacing the current ILS with a microwave landing system (MLS). The new system will eliminate inaccuracies due to interference and multipath errors, providing automatic landing and/or Category III capability and permitting greater approach path flexibility. These advantages offer improved safety and increased airport capacity, permitting curved flight paths and more closely spaced runways and aircraft. Development of the system is expected to be complete in 1977. Installation of operational systems is expected to begin in the U.S. by 1980. The system selection to be made shortly by ICAO is most important in view of the

extremely large export sales potential.

(b) Area navigation systems are to be implemented in three phases commencing in 1977. Significant transition is expected by the end of 1982. Widespread use will result in improved safety, reduced congestion, and operating economics. Seven of the planned VLF navigation aid ground stations will be operating within the next 2 years. Subsequent installation of airborne systems will depend on other factors. Area navigation is not likely to appear by itself, but must come in association with other ATC system changes which will make area navigation attractive.

(c) Satellite navigation systems could be provided in the near future if international agreements can be obtained. Worldwide implementation of 2 dimensional navigation could be achieved in 1981, and 3 dimensional navigation by 1984.

(d) Satellite communication systems will shortly be tested by FAA and ESRO. Again, international agreements including frequency allocation will be required for further development of such systems, which offer improved reliable communications and traffic control. The first launch of an aeronautical communications satellite is planned in mid-1978, the second one in Mid-1979. The system could be operational on the North Atlantic in the mid-1980's, with worldwide application somewhat later.

Additional airborne systems possible in the 1980-1985 time frame include ATC separation assurance devices, digital communications systems, and quite probably a new family of airborne navigation computers and displays which will perform the total navigation and landing job and which will give to crews a new level of information on instantaneous aircraft position and status.

Foreign manufacturers, lacking current models from which to grow derivative aircraft, might offer new designs later in the decade which, particularly if government-supported, could present a competitive threat and might force U.S. manufacturers to abandon derivative plans in favor of earlier development of new advanced technology transports. With difficult financing problems, however, it is doubtful that large new development could be supported. A more likely result of foreign competition appears to be the increased trend toward cooperative U.S.-foreign ventures involving shared production and use of foreign components. This trend has led to some concern relative to technology transfer.

Future developments such as large dedicated cargo aircraft, hydrogen-fueled aircraft, advanced supersonic and hypersonic aircraft, etc., are not expected to materialize during the time period being considered.

BALANCE OF TRADE:

Because of world-wide demand for its reliable high-technology products developed through extensive research and development,

the U.S. aerospace industry is the nation's largest net exporter. Most of the world's transport aircraft and equipment are made in the United States. The steady growth in the U.S. balance of aerospace trade from \$1.6 billion in 1960 to \$7.0 billion in 1975 probably will fall off during the next two or three years as orders for current model aircraft are filled and foreign competition begins to be felt.

The United States will not in the foreseeable future be able to rely on its aerospace industry for increased contributions to the balance of trade position. Exports of aerospace equipment are expected to begin dropping sharply after the initial surge of foreign deliveries of the high unit cost wide-bodied transports and the expected cutback in airlines' capital spending. Transport aircraft sales pace the export performance of the industry. More than 50 percent of the commercial aircraft industry's product is exported, therefore, a high level of activity in the industry is largely dependent on foreign orders for commercial jet aircraft. Present advanced technology, wide-bodied jet aircraft programs, the Boeing 747, the McDonnell-Douglas DC-10, and the Lockheed L-1011, have peaked. In the latter half of the 1970's new export market sales for the aircraft industry will depend heavily on the early commitment of new programs, the derivatives of existing aircraft described in the preceding section.

U.S. GOVERNMENT SUPPORT FOR AVIATION ACTIVITIES:

For many years, the Federal Government has supported and encouraged growth in civil aviation. This policy, which has been based on the needs for military preparedness, public safety, and public service, has been implemented in many ways. Since 1938, the airlines have been paid subsidies totaling more than \$2.0 billion. The FAA budget to operate the airways and several airports has totaled about \$5.7 billion in the last 10 years. In the same 10 years, the aircraft manufacturers spent about \$4.0 billion for civil aviation research and development, while the Government added about another \$3 billion in support. As a result of this support, U.S. civil aviation has experienced impressive growth, especially during the years since World War II. Today, civil aviation is the dominant mode of intercity, for-hire transport, serving almost twice the passenger miles of the combination of all other modes-rail, bus and water. Today, the United States enjoys a well-recognized position of world leadership in aircraft manufacturing and air transportation services.

These accomplishments have been realized even though the U.S. Government provides no direct support to commercial aircraft development, production and sales ventures except through the application of military and National Aeronautics and Space Administration research and development and Export-Import Bank loans and guarantees.

NEW INITIATIVES IN FOREIGN COMPETITION:

Because of increasing foreign competition, the U.S. share of the free world aviation fleet is expected to drop by 1980. While the difference in the number of aircraft is not expected to be great, the avowed intent of foreign aircraft manufacturers and governments to penetrate the world market, if inadequately countered by the United States, will significantly change the fleet composition. For existing technology aircraft--for example, the Boeing 747, the Lockheed L-1011, and McDonnell Douglas DC-10 - the United States will remain the sole supplier. Beginning with the supersonic British/French Concorde and standard wide-bodied twin jets, and continuing with stretched twin-jets, the advanced Concorde, short-takeoff-and-landing (STOL) or vertical-take-off and landing (VTOL) feeder jets, and advanced medium-range transports, new foreign technology is expected to account for an increasing proportion of world aircraft sales.

In addition to the competition from foreign developed and produced commercial transports, foreign governments are actively increasing competition in military sales to support their home industries. Recent studies indicate that the U.S. share of the world military aircraft market will decline from 60 percent in 1970 to 47 percent in 1980.

-19-

Foreign competition is not new to U.S. commercial aircraft manufacturers. The British developed the first commercial jet transport, the Comet, in the early 1950's. Ten years later they were overtaken by Boeing and Douglas. Government financed research and development of the B-47 and B-52 bombers enabled them to do this. Without firm commitment to research and development programs such as those the Government has so successfully supported in the past, the margin required to ensure American preeminence in world aviation markets will become ever more difficult to maintain.

The Concorde, the Franco-German A-300 B Airbus, the French-Italian-Spanish-Belgian "Mercure, "the German-Dutch VFW-614, and the Dutch-German-Irish F-28, for the first time, provide a family of European aircraft which will be able to compete with American suppliers for airline fleet requirements in all markets.

In Europe, especially, there has been a continuing debate over the future of the non-U.S. aerospace industries. At the 1973 Western European Union Assembly seminar on European Aeronautical Policy, there was preoccupation with developing Europe's aeronautic industry unilaterally. At this year's WEU Conference during February 2-3, there was a consensus that although Europe should do everything possible to develop its aviation industry, close collaboration with the U.S. industry is not only desirable,

but a necessity. The major qualification is that cooperation with the U.S. industry must be on the basis of equality. Six propositions developed from the conference, including the necessity for establishing a European aeronautic policy, encouraging cooperative programs instead of mergers, improving commercial after sales support, and developing a competitive program of European aircraft sales in all the markets of the world including the United States.

Recent public announcements indicate that proposals for a unified European aircraft policy are not moving forward as anticipated in the Spinelli Report on European Community Aircraft Policy, which was submitted to the European Community Council in October 1975. The European Community Commission states, however, that although cooperation between the U.S. and the European Community is necessary and inevitable, it should follow agreement by the European industry on a common aircraft policy. The Commission points out that in the absence of a common strategy the current series of bilateral negotiations between aircraft firms of Community member states and U.S. firms would permit the American firms to use European production facilities, technological capacities and public finance to maintain its dominant position in the world market, leaving the Europeans with only a secondary role. The Commission position suggests the best guarantee to ensuring that European aircraft users will continue to procure their equipment in a competitive

-21-

market, would be the existence of a viable European industry capable of developing cooperative ventures with other industries, such as those of Japan and the U.S. on a basis of non-dependence.

The strengths and commitments of the non-U.S. aerospace industries are apparent in the following items extracted from recent reports from U.S. Foreign Service Posts and Aviation Week and Space

Technology Magazine:

- o French Government spending for aerospace research, development and prototypes has increased by 106 percent since 1966, from \$112 million to a budgeted \$231.2 million in 1976. The 1976 budget increased by only 3.5 percent over the \$223 million allocated in 1975.
- o French aerospace export orders during 1975 were valued at \$2.07 billion, slightly down from the \$2.4 billion in the record year of 1974. Export deliveries in 1975, amounting to about half of the industry's total year's production, were valued at \$1.56 billion.
- o British aerospace exports and productivity have been increasing, with 1975 exports valued at \$1.76 billion, setting a record and exceeding 1974 exports by 26.9 percent.
- o Japan's 1975 aerospace exports were valued at about \$37 million, compared to \$27.7 million in 1974, and officials estimate the total could exceed \$680 million in 1980 and \$1.2 billion in 1985 if plans are realized for a commercial

-22-

transport aircraft program in cooperation with the United States and Italy.

- o AERITALIA, the joint Government of Italy/FIAT aerospace manufacturing company, has about 9,500 employees at two factories, with a third to be completed during 1976. Its projects include joint efforts with Convair/McDonnell Douglas as a subcontractor for the DC-10 and DC-9, Dassault-Breguet (France), Lockheed, Boeing, and participation in development and production of the German-British-Italian Multi-Role Combat Aircraft (MRCA).
- o West German aerospace budgets are at a fixed-level for the next four years, leaving little opportunity for new projects except as part of international consortiums. However, the Government is reported to be stressing the importance of the industry maintaining a strong production capacity in commercial, defense and space activities.

The joint DOT-NASA Civil Aviation Research and Development Policy Study (CARD) of 1971 included as Appendix A to a contractor report (Institutional Factors in Civil Aviation, DOT TST-10-1, NASA CR-1807), a survey of the contributions of foreign governments to their civil aviation industries. Briefly summarized, the policies of the various free world governments toward civil aviation research and development were identified as follows:

- (1) Canada's aerospace industry has been subsidized by the government for a number of years, primarily to preserve it as

part of a defense base, but also to enhance its contribution to the balance of trade. Since 1974, the government has been undertaking steps toward reorganization of the industry under Canadian control by buying up the interests of foreign firms, which dominate the industry. In spite of this situation, the government has maintained incentive programs for capital equipment investments, R&D, and production.

- (2) France provides permanent financial assistance to its predominantly nationalized aerospace industry in order to encourage high-technology, maintain a high level of exports and preserve a defense base.
- (3) Germany supports aerospace research and development and has provided substantial funding toward the development costs of several major civil aircraft projects.
- (4) Japan employs a variety of financial devices to assist the growth of its aerospace industry, including outright capitalization, underwriting debentures, loans for production equipment, and funds for research and development in the industry and some universities.
- (5) The Netherlands has a one-company aircraft industry, which is supported by The Netherlands Aircraft Development Board, a government institution established to guide, supervise and finance the development of aircraft in Holland.

-24-

- (6) Sweden has a one-company industry (SAAB), which is assisted on the basis of its importance to national defense.
- (7) United Kingdom aerospace industry activities have been supported by government financial assistance to R&D projects and to the launching costs of specific programs. Nationalization was completed during 1975 and the industry comes under the jurisdiction of the National Enterprise Board.

CONCLUSION:

Since the beginning of the era of controlled, powered flight on December 17, 1903, the U.S. aerospace industry has grown into one of the most important sectors of the national security, as well as a major contributor to the national economy. The highlights of that contribution include the fact that the aerospace industry is one of the nation's largest manufacturing employers, the largest employer of scientists and engineers, and the largest manufacturing net exporter.

The importance of the industry's contribution to the nation's technological progress and its balance of trade cannot be overstated. It is important not only in terms of its own direct exports, but also because of the stimulus it provides to a number of other high-technology industries, which also contribute significantly to the growth of U.S. industrial activity and foreign trade. Such industries as electronics and computers, scientific and industrial instruments, and sophisticated metals

and composite materials depend to a significant degree upon aerospace industry demand for their products.

The U.S. aerospace industry needs new production programs to utilize existing facilities, maintain employment levels, and to aid earnings. The Aerospace Industry Association predicts that aerospace employment will decline by mid-1976 to the lowest level since 1960. Slackening demand in the commercial transport market and a reduction in military aircraft production shapes the decline. Historically, the large domestic airline market has supported the development of new transport aircraft programs despite heavy capital requirements, depending upon the economies of scale afforded by production to meet foreign demand to push these programs toward break-even points and profits. Export markets have helped to maintain the industry's growth and stability and to cover the costs of new technological developments.

At the present time, with some exception, the world airlines face overwhelming problems of the uncertain availability and high costs of fuel, reduced traffic growth, and excess capacity. The United States' major airframe and engine manufacturers are in the unfortunate position of being without sufficient capital to take on any new major risk programs to anticipate future demand, which is estimated at about \$50 billion in new equipment over the next 10 years. The Europeans insist that their aerospace industries be given a much larger share of the future civil aviation market, expressing a determination and

commitment it obtain between 25 and 28 percent of the world market. Accordingly, U.S. companies are looking toward joint development programs of new-generation and derivative aircraft with government-supported foreign manufacturers in order to maintain their market position.

A recent McDonnell Douglas Corporation report states that the three U.S. commercial transport aircraft manufacturers can foresee only 45 to 50 percent of their total market coming from the domestic sector. At the same time, the report continues, lower average production rates and higher average unit costs have resulted in a higher overall break-even point. The net effect, the report concludes, is to require an export share as high as 40 percent before profitability can occur, and to require an export market in order to prevent production line gaps, following the surge of initial orders by competing carriers acquiring new model aircraft as soon after introduction as possible.

As our aerospace trading partners close the technological gap and become more self-sufficient, aerospace export expansion will become increasingly difficult. The concern here is that in manufactured products that are technologically intensive, particularly jet aircraft, the United States has continued to maintain a leading position in world trade. Former Secretary of Commerce Maurice Stans said in statements before the Subcommittee on Science, Research and Development, House Committee

on Science and Astronautics in July 1971, that technology may be the key factor in developing a long-term solution to our trade balance problems. He further stated that the major element of the economic and institutional factors affecting the U.S. trade position which can be influenced decisively for the long run is the level of technological development. The Secretary concluded by stating that the aerospace industry has been the leading advanced technology industry because of its emphasis on research and development, and that it has had to develop capabilities and resources to keep up with a constantly accelerating technological advance and the radically new techniques required to contend with problems of infinite complexity in contributing to national industrial and economic growth.

The magnitude of the industry's current problem in maintaining its world competitive position is that normal market forces cannot be relied upon to support its advantages in high technology. The costs of breaking new ground are higher than private companies or perhaps even private consortia are able to justify because the risks are so great. Other nations have recognized it in the area of research and development and have taken steps to assist aerospace and other technological developments. If the United States is to maintain traditional advantages in aerospace, it remains for the government to accept it as a proper sphere for support and action in concert with industry.

TABLE 1

1/

U.S. and Aerospace Balance of Trade 1960-1975
(Millions of Dollars)

Aerospace

YEAR	U.S. TRADE BALANCE	TRADE BALANCE	EXPORTS	IMPORTS	AEROSPACE % OF TOTAL
1960	\$5,369	\$1,665	\$1,726	\$ 61	31.0
1961	6,096	1,501	1,653	152	24.6
1962	5,178	1,795	1,923	128	34.7
1963	6,060	1,532	1,627	95	25.3
1964	7,556	1,518	1,608	90	20.1
1965	5,852	1,459	1,618	159	24.9
1966	4,524	1,370	1,673	303	30.3
1967	4,409	1,961	2,248	287	44.4
1968	1,133	2,661	2,994	333	234.9
1969	1,289	2,831	3,138	307	219.6
1970	2,708	3,089	3,397	308	114.6
1971	-2,024	3,823	4,196	373	^{2/} N.A.
1972	-6,331	3,242	3,807	565	N.A.
1973	1,567	4,382	5,136	754	279.6
1974	-2,300	6,351	7,095	744	N.A.
1975	11,100	7,002	7,792	790	63.1

1/ Bureau of the Census, and Aerospace Industries Association of America, Inc.

2/ N.A. (Not Applicable)

TABLE 2

AERONAUTICAL TECHNOLOGY PROJECTIONS--LONG HAUL FLEET

- 1975 - '85
 - o Little change--same aircraft or derivatives
 - o Exception: Concorde operational 1976

- 1980
 - o Fuel conservative engine, aircraft components
 - 10% fuel conservation
 - 30% NO_x reduction
 - Modest noise reduction
 - o MLS
 - o Satellite communication

- 1981
 - o Worldwide 2-D Area Navigation

- 1984
 - o Worldwide 3D Area Navigation

- 1985
 - o Earliest possible new subsonic transport with advanced technology (supercritical wing; high Aspect Ratio; composite structure; active controls; quiet, clean, fuel-economical engines)
- or
 - 30% fuel conservation
 - 75% NO_x reduction

- 1990
 - o New subsonic transport with further advances in fuel conservation technology
 - 50% fuel conservation

SOURCE: Working Group 8, International Aviation Policy Review, Department of Transportation, May 1975.

Biography

Richard E. Cohen

U. S. Department of Commerce, Washington, D. C.

Present Position:

Director
Overseas Business Opportunities Division
Office of Export Development
Bureau of International Commerce

March 1963 - September 30, 1973

Manager, Aerospace Industry Programs
Transportation Equipment Division
Office of Business Research & Analysis
Bureau of Domestic Commerce

Responsibilities included participation in the following national policy programs:

"Project Horizon" - National Aviation Goals Study - 1963
International Air Transport Policy Study - 1963, 1969, 1970
Community Economic Adjustment Program (Economic Impact of Phasing-Out Military Aircraft Programs) - 1963
Supersonic Transport Evaluation Team - 1964
Short-Haul Transport Evaluation Team - 1964
Supersonic Transport Development Program - 1971
Civil Aviation Research and Development (CARD) Policy Study - 1971
Preserving of U.S. Leadership in Aircraft Sales & Development - November 1971
New Technological Opportunities Program - January 1972
AMATI Study-Aircraft Manufacturing & Air Transport Industries - 1971
Civil Aviation - National Needs & Opportunities - October 1971

Aerospace Publications:

World Survey of Civil Aviation - various publication in series,
Department of Commerce

Survey & Analysis of the Management of Nonaerospace Diversification in the U.S. Aerospace Industry - Master's Thesis, George Washington University and the Industrial College of the Armed Forces, 1969

Changing Market Environment for U.S. Aerospace Equipment, Department of Commerce, November 1971

New Market Prospects - papers presented at National Meetings, International Committee, Aerospace Industries Association of America, Inc., March 17, 1971, October 28, 1971

Government Considerations for Long Haul Aircraft Markets - paper presented at Air Transportation Conference, Society of Automotive Engineers, May 31, 1972

Implications of Expanded EEC to Future Exports of U.S. Aerospace Industry - Department of Commerce, June 1970.

U.S. Aerospace Industry at the Crossroads - Astronautics & Aeronautics (AIAA), November 1973

Aerospace Awards:

Letters of Commendation - Federal Aviation Agency, June 23, 1964
Short Haul Cargo-Passenger Aircraft Development Program;
Special Consultant to the President, January 28, 1972,
New Technology Opportunities Project

Citations - Federal Aviation Agency, April 14, 1964, U.S.
Supersonic Transport Development Program; Federal Aviation
Administration/Department of Transportation, September 15,
1971, U.S. Supersonic Transport Development Program

"Achievement Award" - Aero Club of Washington, November 1965,
Assistance to U.S. Aircraft Manufacturing Industry in
Competing Successfully in International Aviation Market

Who's Who in Aviation

Professional Aerospace Association Memberships:

Aero Club of Washington
American Institute of Aeronautics and Astronautics
International Aviation Club
National Aeronautics Association

-3-

Education:

George Washington University, Washington, D. C.
B.A. in Business Administration (Marketing and Foreign
Trade - 1958)

Graduate Study in Law and Economics
Master of Science in Business Administration (MSBA) - 1969

Industrial College of the Armed Forces, Fort McNair,
Washington, D. C., 1967-1968 - resident course for command,
staff, and policy making positions in national and inter-
national security management and industrial management

Military Experience:

United States Army 1944 - 46 (combat service with Ninth Infantry
Division, European Theatre of
Operations).

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HARRY E. COLWELL III *Vice President*

May 17, 1976

The Honorable Dale Milford
Committee on Science and Technology
U. S. House of Representatives
Suite 2321 - Rayburn House Office Building
Washington, D. C. 20515

Dear Congressman Milford:

Attached is my contribution to the testimony for your Subcommittee which I hope will prove useful. I had the pleasure of hearing your address to the ALTA group in New Orleans last week and find that you already have a good grasp of this key subject. I do hope that you and your associates recognize the dangers that are involved in the Aviation Act of 1975 and similar bills which could really undo all that you hope to encourage by doing grave damage to the airline industry, or at least postponing any actions until the effect of the legislation is better understood.

With best wishes.

Sincerely,

Harry E. Colwell III

Statement to Subcommittee on Aviation and
Transport R&D of Committee on Science and Technology
U. S. House of Representatives

My name is Harry Colwell. I am a Vice President of Chase Manhattan Bank, N.A. and Division Executive of its Aerospace Division. I have been involved in the financing of airlines and aerospace companies for the past twenty five years. I am not an engineer, so my comments are of a general, not a technical, nature.

The future of aviation is one of continued growth in airline traffic, both passenger and cargo, and further development of the technology of the aircraft produced. This is reason to doubt that the explosive growth of passenger traffic will continue at the explosive rate of the past decade, due to some saturation of the market and ecological restraints, but there will be growth and demand for safe, speedy and dependable air service on both a scheduled and a charter basis. The cargo growth should grow faster than passenger, especially if a new, all cargo plane can be developed that can substantially lower ton-mile costs. Barring the collapse of the industry as the result of radical experimentation with the regulatory process, the airline industry should be able to regain a degree of financial health and be in a position to buy new aircraft to meet their increased traffic and to replace obsolete and ecologically unacceptable equipment. It is my opinion that this will occur in the early '80s.

As a result of the above assumptions, there is a growing requirement for the American manufacturers of commercial transport aircraft to be in a position to develop new, advanced technology aircraft

Continued

that will meet the needs of the 1980s. Clearly, there will be requirements for several types of aircraft that will meet the airline demand for properly sized planes with appreciably lower operating costs. These airplanes will need to incorporate many new concepts, such as new, more efficient and clearer engines, composite structures for weight saving and break throughs in aerodynamic design. The greatest need is for planes that will be not so much faster than today's subsonic equipment but cheaper to fly and users of less petroleum, less airspace and with appreciably lower noise levels. Whether supersonic aircraft are needed in the next generation is moot, and the results of the Concorde experience will largely determine this. A new start-from-scratch cargo plane is also an obvious need, one suited to commercial freight.

The cost of developing these new aircraft is staggering, with each new type requiring approximately one billion dollars or more for the development and tooling alone, plus additional staggering sums for the production costs. This level of cost is beyond the ability of any private corporation to raise, both from the sheer amount of the investment and from the risk aspect which is a part of any new, beyond the state of the art program. Undoubtedly, new forms of cooperation and coordination between all the parties involved will have to be developed, if we are to proceed -- and we have no choice but to proceed. How the aerospace companies, the airlines, the government, the financial community, the shareholders, and the general public will be able to work out satisfactory, viable vehicles is hard to see, but I am convinced that it can be done.

Continued

Certainly, the Government will have to play a key role and it is to its best interest so to do. For not only is the future prosperity of the nation directly tied to a continued efficient transportation system, but there are key national defense aspects involved as well. One of America's key resources is the creative, innovative teamwork of engineers, designers and production people represented in our aerospace manufacturing companies. These teams are collections of rare talents, developed by interaction over years, and able to cope with the unbelievably intricate task of creating the modern jet transport plane. Without new aircraft to be developed, we are in danger of these teams disintegrating. It is these same teams that also originate our advanced bombers, fighters and sophisticated missiles.

There are many ways the Government can help in this matter. Continued basic research by NASA is a must, especially in the development of concepts and processes on the frontiers of technology which can be freely used by the manufacturers in their new designs. Also, some form of direct participation in the R&D of actual aircraft can be worked out. The British Government has for some years contributed to such start-up costs on a basis whereby the contribution is repaid from the proceeds of the aircraft sold. There is a risk sharing element in the process which is essential. Obviously, other potentials exist which could include Government guarantees of bonds issued for the single purpose of development, or even an R&D Corporation set up to facilitate this type of investment.

Continued

It is necessary to emphasize, however, that there be no interference with the market being the decisive arbiter of whether and what aircraft are to be developed. There can be no "make work" programs or prestige seeking allowed to determine what is done, but the hard realities of what aircraft the airline customers need and are willing to acquire with their hard earned money. It is critical to keep in mind that only an economically healthy airline industry which can be able to attract the confidence of lenders and investors, who will have to put up the purchase money, that in the end makes the technological development worthwhile.

America is rapidly approaching a critical decision point on this matter of whether a new generation of aircraft will be developed to meet the challenges of the future and, to combat the cost increases of inflation, and to conserve precious fuel. There are few decisions that will affect more people and money than this one, and it is encouraging to us who support the key role of aviation to see Congressional action being taken at this time.

THE FUTURE OF AVIATION - UNITED AIRLINES' VIEW

STATEMENT OF ANDREW M. DE VOURSNEY
GROUP VICE PRESIDENT - FINANCE AND PLANNING
UNITED AIRLINES, INC.

to

SUBCOMMITTEE ON AVIATION AND TRANSPORTATION R & D
COMMITTEE ON SCIENCE AND TECHNOLOGY
U. S. HOUSE OF REPRESENTATIVES

May 14, 1976

5/14/76

THE FUTURE OF AVIATION - UNITED AIRLINES' VIEW

Andrew M. de Voursney
Group Vice President - Finance and Planning

SUMMARY

The need for capital formation is perhaps the most pressing, unsolved problem now facing the airline industry. Analysis of the future demand and supply of investment capital indicates there is a significant threat of a shortage of capital which could have serious consequences for air transportation. The financial performance of the industry must be significantly improved in order for it to attract needed new capital which is far in excess of the industry's current capitalization. Based on relatively conservative assumptions as to obsolescence, growth and inflation, we estimate the investment needs of the industry will amount to \$162 billion between 1978 and 2000 compared with current capitalization of \$11.8 billion.

United's forecast of future market growth is an integral part of its continuing long range planning activities. Strong favorable trend growth factors indicate continued market expansion. Air travel demand tends to rise and fall relative to the trend as the economy experiences cyclical swings. A significant change in the future will be the end of the long term decline in the "real" cost of air travel to the consumer; rising operating costs, a slowdown of technological progress and the need to restore adequate profit margins indicate that airline fares in the future must follow operating costs more closely. United's planning forecast predicts a growth rate for domestic scheduled passenger traffic of 5.4% per year from 1975 to 1981 and 3.2% per year from 1981 to 1990. We predict charter travel will grow more rapidly, averaging 25% per year to 1981 and 15% per year thereafter.

In the near term, we expect no major change in the relatively low government priority assigned to air transportation R & D. The most critical technical problem needing a rapid solution is the restriction on airport movement capacities due to increased aircraft separation to avoid wake vortices. A solution to this problem can save billions of dollars through avoiding the need for new or expanded airports. Development of new aircraft designs is closely related to restoration of airline financial health. The useful life of current generation equipment is now realistically viewed as about 20 years. A high long range R & D priority should be assigned to development of alternative aviation fuels.

* * *

5/14/76

THE FUTURE OF AVIATION - UNITED AIRLINES' VIEW

Andrew M. de Voursney
Group Vice President - Finance and Planning
United Airlines, Inc.

At a recent United Airlines management conference, I presented a talk on the United Airlines of 2026 - a 50-year forward projection on the occasion of our 50th Anniversary of scheduled airline service. This speech has been widely reprinted and has provoked a variety of reactions. Although it was presented in a lighter vein, and included a generous amount of pure imagination, considerable substantive research went into the preparation of the inputs to the speech. A one page excerpt as printed in Aviation Week of February 16, 1976 is attached to this paper.

Many of the questions addressed in that paper coincide with the Subcommittee's Hearing Outline agenda. Based on United's internal research studies we have prepared commentary on the following subjects in the Outline:

1. The need for capital formation
2. Growth patterns affecting air transportation
3. Industry View - R & D Policy

The Need for Capital Formation

The need for capital formation is the most pressing, unsolved problem now facing the airlines. Our analysis of the U. S. economic outlook for the coming decade has convinced us that a possible shortfall of real capital investment is a significant threat to future maintenance of an adequate level of economic activity. An inadequate level of saving and investment can in the long run only reduce real income level on a per capita basis. In recent years we all have become aware of growing needs for capital investment to pay for energy independence, the costs of pollution control, industrial safety, and other social costs which we tended to ignore in the past. In a broader sense we also need increased investment in human capital in the form of education, job training and research to produce more qualified workers and new and more efficient processes, products and services. In our modern industrial economy a growing level of capital investment will be required in order to provide enough jobs to keep the labor force fully employed. Finally, shortages of all kinds may develop if the productive capacity of the economy is permitted to fall as a result of inadequate long range capital investment.

The prospects for a future capital shortage in the United States depend both on the level of demand for investment capital and the supply of savings. Most studies suggest that investment demand will increase from historical levels of about 10-1/2% of Gross National Product to 11-1/2%. This small increase would not appear to present an insurmountable problem; however we foresee a problem in the source of savings needed to provide necessary capital. Savings by the household sector, which provide about one-third of the total, may be reduced because of a demographic shift in the population mix; we will have relatively more people in the high spending, low saving age brackets (24 to 39 years and over 65 years) and fewer in the high saving middle-age brackets. Second, business savings - retained earnings and depreciation - have been seriously eroded by inflation and inordinately high taxes on corporate profits as compared with those in the rest of the world. Most economists favor reforms to improve the ability of the corporate sector to generate cash flow for future investment. Third, the government sector has had a negative impact on savings because of its chronic large budget deficits. Nearly all studies of the capital formation problem agree that government budgets at the federal, state and local levels eventually must be brought into balance in order to prevent a crippling savings shortfall.

We believe that the consequences of this capital formation problem for the air transportation industry are potentially extremely serious. Just as the era of cheap energy is a thing of the past, so is the era of readily available low cost capital. Business firms must be both large and possessed of a better than average financial track record to compete in the future financial marketplace for investment capital. At the present time we have no large airlines with an acceptable financial history. Some smaller airlines are relatively strong but the Big Five carriers have financial structures and profit records which put them at a serious disadvantage in competition for new capital. Measures currently under consideration under the general heading of deregulation may have the effect of further weakening the carriers. Unless significant steps are taken to improve the financial performance of the airline industry, it is probable that the industry will be unable to attract the new capital needed to replace its aging fleets with new efficient, ecologically acceptable aircraft.

We have made some broad estimates of the amount of new investment that will be required by the airline industry through the end of this century. These projections have been based upon very conservative assumptions with respect to the rate of growth of air travel, the rate of replacement of existing capital equipment and the rate of inflation. Furthermore, the

estimates cover only the passenger equipment needs of the major airlines and thus exclude their all-cargo requirements as well as the requirements of the all-cargo airlines, supplemental airlines, local service airlines and non-certificated airlines. The key assumptions are that all narrow-body jets now on hand and on order (approximately 1,400 aircraft) will be replaced on a straight line basis beginning in 1978 and ending in the year 2000. The replacement will be on a seat-for-seat basis. The growth assumption is for capacity to increase by 5% per year starting in 1978. The investment cost assumption allows for an average aircraft cost of \$90,000 per seat (i.e., a 250-seat airplane would cost \$22.5 million) plus an allowance of 34% for spare parts, new ground equipment and new facilities. The inflation rate is estimated to be 4% per year.

On the basis of the foregoing assumptions we have calculated that the airlines must spend approximately \$36 billion between 1978 and the year 2000 to replace narrow-body equipment plus \$126 billion to provide for market growth - a total capital investment of \$162 billion. Of this total \$57 billion would be expended by 1990 which would require an average outlay of over \$4 billion per year for the years 1978 through 1990 inclusive. To put these estimates in perspective, the original cost of current airline fixed assets is approximately \$15 billion, excluding the value of leased aircraft which adds another \$3 billion. The large carriers' book investment amounts to approximately \$9.5 billion of long term debt plus equity; to this may be added another \$2.3 billion to cover the remaining principal value of leased aircraft for a total capitalization of \$11.8 billion. An investment requirement of \$4.3 billion per year exceeds one-third of the total current capitalization of the industry.

The ability of the airline industry to compete for these funds in the capital market will require a substantial permanent increase in the financial strength and profitability of the industry. To date we believe that the need for this improvement is not fully recognized by those in government who are charged with regulation and promotion of aviation.

Growth Patterns Affecting Air Transportation

United's long range planning always has included the preparation of long range forecasts of the air travel market. Our most recent long range forecast is the basis for long range planning activity in the forthcoming year and is based upon three primary factors: 1) trend growth factors, 2) the relation of air travel demand to GNP, and 3) the price of air travel in constant dollars.

We have identified a number of significant trend growth factors which influence demand for air travel. The principal positive growth factors include population growth, the trend to smaller families, the rapidly rising number of high income households, the trend growth in discretionary purchasing power, the trend increase in leisure time, changes toward more sophisticated life styles, less use of private automobiles for long distance travel, an increasing number of foreign visitors to the United States and the emergence of a low cost air travel market primarily as a result of the relaxation of charter rules. We have also noted some negative trend factors. These include the problem of availability of substitutes for business travel in the form of sophisticated communications equipment, a tendency for a higher consumer savings rate, and some dampening effect of a rising fare level for air travel.

Over the long run we observe a close relationship between total spending for air travel and overall economic conditions as measured by changes in Gross National Product. For many years prior to 1970, the ratio of spending on air travel to Gross National Product in current dollars rose steadily. By 1969 it had reached a level of 60.3¢ per hundred dollars of GNP. Since 1969, a period during which the economy has suffered two major recessions and significant social and political upheaval, this ratio has tended to grow more slowly. By 1975 it had reached a level of 63.2¢. We believe that, in the future, this relatively slow rate of increase in the ratio will accelerate modestly.

The third component of our forecasting approach involves an estimate of the cost of air travel to the passenger. Through detailed analysis and projections of airline operating costs, productivity and load factor we have estimated that the future price of air travel in real terms can no longer continue to fall. In constant 1967 dollars, the real cost of air travel was 6.48 cents per revenue passenger mile in 1965. By 1970 this had fallen to 5.29¢. As inflation heated up, the real yield remained relatively flat until 1975. As a result of the failure of the Civil Aeronautics Board to permit the pass through of higher operating costs and, as a result of the introduction of new broadly based discount fares, the real cost of travel per passenger mile dropped by 6.8% from 5.29¢ in 1974 to 4.93¢ in 1975. This reduction in real yield had a sharp impact on airline earnings. In our opinion the only hope of restoring airline profitability in the near term is through restoration of an adequate revenue yield rate. This suggests that further declines in the real cost of air travel are not likely in the near future. For planning purposes we expect revenue yield changes will follow changes in operating cost levels.

On the basis of the foregoing methodology and assumptions, we predict that the demand for air travel will increase in dollar terms by 13.4% per year between 1975 and 1981 and by approximately 10% per year between 1981 and 1990. In terms of physical volumes (revenue passenger miles) we are projecting growth of scheduled airline traffic of 5.4% for 1975 to 1981 and approximately 3.2% per year from 1981 to 1990. We have not prepared forecasts beyond the year 1990.

The preceding forecast is for scheduled airline traffic. However, as noted, we believe that the charter portion of the market will tend to grow more rapidly and will increase from approximately 4% of the domestic market today to well over 10% in the 1980's. We believe that charter growth will approximate 25% per year for the balance of this decade and 15% during the 80's.

With respect to domestic air cargo we believe that the rapid growth rates of the past will not be repeated in the future. Our plans are based on a long range growth rate for air cargo of approximately 5%. However, we note that the growth rate for international cargo should significantly exceed this rate.

Industry View - R & D Policy

In assessing the outlook for air transportation technology we have observed that current government priorities for support of R & D appear to give air transportation technology a low rank. We do not anticipate any significant near term change in this situation. Therefore we believe that R & D attention should be focused on the most critical problem facing air transportation which we believe to be the restrictions imposed on airport movement capacities due to increased separations to avoid wake vortices. In order to eliminate the excessive fuel burn and costs of inbound holding delays and to avoid multi-billion dollar capital investments for expanded or new airports these separations must be reduced safely. In the near term we believe that the FAA can implement wake vortex detection and avoidance systems at major airports and can install automation for air traffic metering and spacing linked to these systems. In the longer term we expect that R & D by NASA and the airframe manufacturers will develop wing tip devices or new wing designs which can minimize wake vortices at their source.

With respect to the financing of R & D we believe the private sector will probably not be able or willing to finance any major new aircraft developments. Current attention to "design derivative" aircraft is clear evidence of the real world limitations in this area.

In our long range planning environmental forecasting we have estimated probable technological developments which will be significant. These forecasts do not represent United Airlines' assessment of what would be desirable in this field; rather they are an attempt to estimate what actually will occur.

1. Fuels and Propulsion (including noise suppression)

No radically new engine designs and no significant improvement in specific fuel consumption are expected from inservice engines in the next five years. Within the next decade we can achieve a 4% to 6% reduction in specific fuel consumption, primarily through the application of advanced technology airfoils to turbines and compressors, higher pressure ratios and elimination of sound suppressor losses by more advanced noise technology. No significant reliability improvement over the best current mature large fan engines is likely.

Fuel will be kerosene throughout the next decade. No liquid hydrogen transport aircraft is on the horizon even though hydrogen is promising for the very long range future. Research on the development of alternative aviation fuels should receive increased support.

Noise regulations could be made somewhat more stringent than existing FAR 36 over the long run. Fuel conservation requirements will act as a constraint against the use of some noise suppressing technology, but engines will be as quiet as today's best. The net effect of noise suppression and fuel price changes will be an increase in the cost per aircraft mile for fuel consumption and propulsion system maintenance.

2. Navigation and Avionics

The primary technological changes to existing systems in this area will be conversion to digital rather than analog hardware. Several new technology systems will be commercially available including area navigation (short range), OMEGA (long range navigation), micro wave landing

system, collision avoidance, solid state single side band HF radio, satellite communications, datalink, integrated drive or variable speed constant frequency electrical generators, and fly-by-wire automated flight control. Purchase decisions for these new systems will depend on trade-off economics except in the case of collision avoidance where implementation of a system could be influenced by regulatory pressures.

3. Materials

In the short run, few changes are anticipated. Increasing amounts of adhesive bonded structure and titanium, limited use of graphite-epoxy composites, and more acoustical composites inside engine nacelles are anticipated. Aircraft interiors will use more fire resistant low smoke and low toxicity plastics. In the long run, the introduction of aircraft materials that optimize high payload and low weight including filamentary composites, primary bonded honeycomb structure, composite fan blades, vanes and landing gear parts, and use of high strength materials are expected. These new materials present problems with respect to supply, price, repair costs, production and changes in maintenance concepts. United believes the industry should encourage NASA research in composite structural materials, metal corrosion resistance and protection, interior crash and fire dynamics. Airline management attention is needed to critical material identification, supply strategy development, alternate material studies, recycling, and optimization of materials use. Maintenance techniques and cost management will become more important.

4. Systems

Advanced active flight control systems will be incorporated in new aircraft designs available in the late 1980's. No significant mechanical system technology changes are expected in the next decade. Cost benefits associated with extension of maintenance task periodicities will be minimal. Active flight control systems may foster reappraisal of flight crew functions.

5. V/STOL and Helicopter

Vehicle technology study will continue on a relatively small scale. Environment and economic constraints will prevent significant use of V/STOL for scheduled air transportation. However, commercial helicopter designs will be much more efficient vehicles than existing machines for specialized helicopter roles (not airline use). It would be in the industry's best interest to encourage reallocation of funds planned for air transport V/STOL R & D to city/suburban airport ground transportation links; the commercial potential for V/STOL appears to be minimal.

6. SST/HST

Environmental and economic constraints will prevent use of SST or HST in overland domestic service.

7. Obsolescence

Concentration of design activities on derivative aircraft insures that technological obsolescence of existing airline fleets in the next five years is extremely unlikely, and unless some major change in aerodynamics, propulsion systems or structures technology occurs, this period is more likely to be ten years. With the exception of early generation jets with non-fan engines, we believe a 20 year useful life is a realistic expectation for current jet designs. Major changes which may occur include application of such present R & D concepts as the super critical wing and high mach number turbo props. Thus, it is increasingly important that airlines maintain existing equipment for long use and avoid short-sighted maintenance economies. Encouragement of NASA research in areas most likely to produce a significant net improvement in operating economics is desirable.

Although United has not considered in depth the appropriate role of various government agencies in supporting aviation R & D, we note that little practical commercial fallout can be expected from military R & D, which is concentrating in areas with low commercial payoff, specifically, the supersonic capability of combat aircraft and the V/STOL capability of military transports.

* * *

The Future Airline

(Andrew M. de Voursney, group vice president-finance and planning for United Airlines, Inc., outlined recently how he thinks an airline might look 50 years from now.—Ed.)

We will have a different airline industry in 2026. The CAB will have been abolished as Congress will have deregulated the industry. In 2026, just three surviving carriers will constitute the U. S. domestic and international trunk network—each with unrestricted access to all domestic points and with service overseas. These three trunk airlines will be augmented by half a hundred commuter carriers which will supply short-haul services. All carriers will be privately owned and managed.

United's domestic map will no longer be a route map, since we can serve any pair of points we choose. We will be serving many new cities and new areas—among them Dallas, Houston, Phoenix, St. Louis and more.

Of course, United will span the world, serving every continent and holding a dominant position in the important U. S.-Japan market. In the world market, flag carriers of many smaller nations will have disappeared.

Even at our modest predicted growth of 4.4% per year, industry passenger miles will multiply nine times over the next half century—attaining a level in excess of one trillion revenue passenger miles. United's expanded 40% market share will give it over 15 times its 1976 volume. On an average day in 2026, we will board over one million passengers.

Air fares will reflect cost inflation but, thanks to productivity gains, will move up less than wages and prices. Against an average inflation rate of 4%, air fares will advance only 3.5% as the carriers, though free of CAB restraint, will set prices for market growth and profit. Even with such restraint, yield per passenger mile will exceed 40 cents.

Discount fares will be long gone. First class service will have disappeared early as a result of CAB actions and will not be brought back under deregulation. The corporate supersonic jet will have siphoned off top management business travel. There will be two types of service, single class scheduled flights and charter operations.

Some representative fares will be:

- Chicago-New York—\$430.
- Chicago-San Francisco—\$820.
- New York-Honolulu—\$1,600.

While seemingly high, these fares will be a bargain in real dollars. As for other travel costs, the widely advertised Continental Plaza \$36 room will cost \$255 in 2026.

United's fleet will change radically. Even at the high load factors of 2026, we will have over 800 airplanes—all but two will be products of the Bomac Aircraft Corporation, our single source U. S. vendor since the consolidation of the U. S. manufacturing industry in 1986. All aircraft will be leased from the bank of Saudi Arabia.

Here is our fleet of 2026:

Bomac	Type	Seats	No. in Fleet
1000	SST	500	45
900	Super wide-body	1700	70
800	Airbus	800	240
700	Charter	500	150
600	Short haul	250	250
500	Freighter (300 Tons)		45
Convair			
580	Short haul	44	2
Total			802

The 500-seat advanced SST primarily will be used on

international flights—and to Hawaii. It will fly on domestic routes at 1.2 Mach without a sonic boom. It will feature a variable sweep yawed wing.

The Bomac 900 super wide-body will be the double-deck giant of the fleet with 1,700 seats and a gross weight of 1.5 million lb. The strange looking wing tip devices (or winglets) use technology developed by nature for eagles' wings. They suppress wing tip vortices. Twenty landing gear units are required. Passengers are accommodated in the wing in 24 individual compartments each with 72 seats, equipped with an individual galley and lounge, and entered directly from the boarding area.

For shorter haul services in dense markets the Bomac 800 airbus, also double-deck, will predominate.

The 500-seat Bomac 700 will fill our charter needs. It will be a 747 derivative with a 30-year life.

Present day 737 and 727 routes will be served by the Bomac 600, at 250 seats.

The Bomac 500 airfreighter will have a payload of 300 tons with 8 x 8 cargo containers carried four across in the two lobes.

And for Ely and Elko, the good old Convair 580.

At 2026 prices, airplanes will be expensive. Today's \$90,000 per seat will climb to \$600,000, making each seat in the super wide-body more expensive than a DC-6. Incidentally, Bomac will be asking about a billion dollars for each super wide-body 900. In 2026, our engineers and fleet planners will be evaluating our next step—a suborbital hypersonic aircraft capable of cruising at Mach 6 at 100,000 feet.

The customer of 2026 will experience the greater size of aircraft and the all-economy interior with higher seating density. Inflight entertainment will be much expanded with a wide choice of features available. Audio will be true high fidelity and live events will be displayed with ease on the viewing screens. On the ground, however, reservations, ticketing and the check-in process all will be quite different. You will purchase your ticket using your home or office computer. Push a few buttons and you will receive a printout of available schedules, make your reservation, and receive a printout confirming your flight number, destination and seat. At the airport, you will insert your transaction card in the check-in machine. It will confirm your identity, greet you by name, check your reservation, record you on the manifest and charge your bank account for the correct fare—all with a smile in the mechanical voice. No paper will change hands.

As for personnel, the friendly skies of 2026 still will be a people business, although the computer will have contributed to steady gains in productivity. Our 168,000 employees will be deployed over our 50,000 mile system in 200 cities worldwide. Our average salary will be \$217,000, compared with \$18,000 today. Pilots will continue to be well paid. The captain of a Bomac 600—our smallest airplane at 250 seats—will get \$480,000 a year for his labors in our centennial year.

What have I forgotten? Oh, yes, the financial results for 2025:

- Operating revenues, \$183,600,000,000.
- Operating expenses, \$160,000,000,000.
- Operating profit, \$23,600,000,000.
- Net earnings, \$11,800,000,000.

Some of you may disagree with this forecast of our future. Before you challenge it, take yourself back to 1926 and ask: "How would I have pictured the United Airlines of 1976?" Our successors in 2026 no doubt will look back to 1976 much as we look back today to our elementary beginnings of 50 years ago.

NATIONAL COMMISSION ON SUPPLIES AND SHORTAGES
The Winder Building, 604 Seventeenth Street, N.W.
Washington, D.C. 20506

FOR IMMEDIATE RELEASE

Wednesday, September 17, 1975

For information call:
634-4190

GEORGE C. EADS
APPOINTED
EXECUTIVE DIRECTOR
NATIONAL COMMISSION ON SUPPLIES AND SHORTAGES

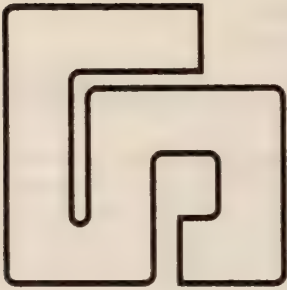
Dr. Donald B. Rice, Chairman, National Commission on Supplies and Shortages, announced today selection of George C. Eads to be Executive Director of the Commission staff. Eads' appointment was approved by the Commission in its meeting held September 16, 1975. Eads comes to the Commission from the Council on Wage and Price Stability where he was Assistant Director for Government Operations and Research. Prior to assuming this post, Mr. Eads served briefly as a project director at the National Science Foundation. His previous experience includes teaching economics at George Washington University, Princeton, Harvard and Yale. He also spent one year at the Department of Justice as Chief Economic Advisor to the Assistant Attorney General, Antitrust Division.

The bulk of Mr. Eads' published research has dealt with the question of the impact of government regulation on the private sector. He has served as a consultant to the Department of Transportation, Civil Aeronautics Board and the Council of Economic Advisors. He has testified as an expert witness before the CAB and the U.S. Tariff Commission.

A 1964 Summa Cum Laude Graduate in Economics from the University of Colorado, Mr. Eads received his MA and PhD from Yale in 1965 and 1968. He was born in Clarksville, Texas, and raised in Yuma, Arizona.

Mr. Eads and his wife Margaret reside in Washington, D.C.

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SUMMARY

The author discusses what he perceives as a major gap between the economic concept of externalities as a justification for US Government intervention in the process of developing commercial technology and the direction that, in practice, this intervention appears to be taking. He argues that, unless the economics profession provides an operational concept of externalities for use by decision makers and monitors the application of that concept to specific situations, externalities may be discovered primarily whenever it is politically advantageous to do so.

US government support for civilian technology: economic theory versus political practice

by

George EADS

The George Washington University, Washington, USA

During the last two years the US Government has undertaken a new series of initiatives designed to stimulate increased commercialization of advanced technology with the twin aims of improving domestic efficiency and enhancing international competitiveness. These new initiatives have been justified, at least in part, by an appeal to an economic concept known as externalities. Perhaps the most concise statement of the basic theory of externalities and its policy implications for US Government involvement in private R & D investment decisions was contained in the 1972 Economic Report of the President's Council of Economic Advisors [1]:

"...Government has an appropriate role in R & D even when its results will not be incorporated in Government purchases, because private firms would underinvest in R & D for goods normally purchased by the *private* sector. Although an investment in R & D may produce benefits exceeding its costs from the viewpoint of society as a whole, a firm considering the investment may not be able to translate enough of these benefits into profits on its own products to justify the investment. This is because the knowledge which is the main product of R & D can usually be readily acquired by others who will compete away at least part of the benefits from the original developer. This is particularly true of basic research, where the output frequently occurs in the first instance not as a marketable product, but rather as an advance in basic knowledge that can subsequently be used in applied research and development by a wide and often unforeseeable range of firms."

Language similar in tone also appeared in the President's Message on Science and Technology, delivered March 16, 1972, in which the nature of the proposed US Government initiatives was detailed.

Such statements ought to bring joy to the hearts of economists interested in

the rationalization of US Government support for commercially oriented science and technology. They contain an explicit recognition that the principal justification for such support is the failure of markets to perform their job adequately. More significantly, implicit in the President's message is a commitment that the new programs he was announcing were designed to supplement, not supplant, the market. Their aim was to create a set of institutions to diagnose and correct market failures so that the market then could be relied upon to provide correct signals for private investment in technological change.

However, any such joy ought to be tempered with anxiety as to what is likely to be the result once these admittedly admirable intentions begin to be implemented. Indeed, there is ample precedent for concern. The economic history of the United States is full of attempts by the government to correct through direct intervention what have been perceived by some as failures of markets to direct economic activity properly. The regulation of the railroads is an early example. The decision to undertake economy-wide wage and price controls is a more recent one. However, in an unfortunately large number of cases, these attempts have been unsuccessful. The market failures, either real or imagined, have not been corrected, and, what is worse, a host of new distortions have been created. In certain cases the performance of industries subject to direct economic regulation has been so dismal that legislation has been proposed that would substantially decrease the scope of regulation and increase the reliance upon markets, imperfect though they may be*.

Therefore, though I am encouraged by the fact that the general nature of the market failure justifying government intervention has been correctly perceived, and though I am heartened by the stated resolve of the current administration to employ solutions appropriate to the problem, I am extremely apprehensive about what is likely to be the outcome when government bureaucrats, operating in a highly charged political atmosphere, attempt to improve upon the workings of impersonal markets. My apprehension is heightened by the way I see actual US Government science and technology policy developing. Already there is a large gap between the admirable stated intentions and actual practice. This gap is caused in part by the fact that the theory of externalities and the conditions under which its simplest prediction

* The Regulatory Modernization Act, introduced in the fall of 1971 by the Nixon Administration, which proposed relaxation of rate regulation and freer entry for surface freight transportation is one example. The deregulation of natural gas prices, proposed by the Administration in 1973, is another.

is a proper guide to policy have not been clearly understood by those formulating US Government science and technology policy. This misunderstanding has been abetted by the failure of economists to present the theory of externalities in an operational form. We economists have given policy makers a theory that possesses a great deal of political attractiveness, but we have failed to develop the tools that would allow us either to show those government officials charged with implementing science policy how the theory should be applied in specific cases or to demonstrate to them and to the public that the theory is being misapplied. This is not to say that economists are powerless to point out gross misapplications of the theory. This can, and obviously should, be done. In most cases, however, the proper policies may not be obvious even to economists, given our current state of understanding. Therefore economists should not be too quick to criticize when policy makers, confronted with an attractive theory and faced with the political imperative of doing something, proceed to produce what may look like bad policy.

Let us first focus on why the simplest predictions of the theory of externalities may prove an inaccurate guide for the formulation of technology policy in specific industries. The basic assumption underlying the prediction of a tendency towards underinvestment in technological change by private industry is that currently decisions are being made in an otherwise neutral atmosphere. That is, it is assumed that the absence of a mechanism designed to allow capture of externalities is the only market-distorting force in operation. This assumption clearly is violated in practice. For example, in certain oligopolistic markets, by tacit agreement of the firms involved, competition has been directed away from price and towards product improvement. The firm that has been able to offer a slightly improved product has been able to gain a substantial edge over its rivals. This has meant that to survive in such industries, firms have been required to devote a share of the resources that otherwise might have represented profits accruing to their market position to research, development, and new product design. Prices have been held higher than they would have been under more competitive market conditions, and the rate of technological change in the industry has been increased. In certain cases the sum of investment in technological change by individual firms responding to such incentives may already exceed the socially optimal level. Or to state the result in more technical language, due to the peculiarities of market structure and product characteristics which channel competition into nonprice areas and which channel nonprice competition into competition for product improvement, the private rate of return to innovation may in some

cases exceed the social rate of return, leading to an *overcommitment* of resources to the process of technological change*.

Another factor influencing the rate and direction of private investment in technological change is the substantial US Government influence, both direct and indirect, that already exists. Since the early 1950's the US Government has consistently provided more than half of the funds going to support research and development, though to be sure, support has been concentrated in a very few sectors, primarily those concerned with defense and space technology [3]. This funding has produced the knowledge base for many of our most technologically advanced industries. As important as this direct influence has been, however, the indirect governmental influence on technological change may have been even greater—particularly in the majority of industries which were not among the beneficiaries of this largesse. Among such indirect influences have been the following:

- The US Government is a major purchaser of goods and services; even in some non-defense industries it may represent the largest single purchaser**.
- US Government programs which are designed to promote broad social aims, such as Federal Housing Administration loan guarantees, Rural Electrification, Medicare and Medicaid, grants to local communities for improved police protection stimulate demand in these areas.
- The national, state, and local governments subject major sectors of the economy to direct economic regulation***.
- Industry in general is subject to the influence of the tax laws, the regula-

* This point was suggested by Harvey Brooks, who singled out the pharmaceutical industry as an example where an overcommitment of resources to technological change may have occurred as a result of this phenomenon. An article by Comanor [2] suggests that the tendency toward higher levels of investment in technological change for competitive reasons exists throughout the consumer durable and investment goods sectors.

The argument presented here is nothing more than a variant of the well-known proposition that the amount of nonprice competition in oligopolistic markets is likely to be higher than socially optimal. Ordinarily the only type of nonprice competition considered is advertising, yet new product development may be an equally expensive and, in some cases, more competitively effective means of nonprice competition.

** For a discussion of the effects of US Government procurement on the incentives to innovate and how these effects might, in the view of the authors, be profitably redirected, see Nelson et al. [4].

*** Scherer estimates that in 1965 the industries subject to direct economic regulation contributed 10.9% of the nation's GNP [5].

tions of the Environmental Protection Agency, the anti-trust laws, and the patent laws.

Wherever these regulatory or quasi-regulatory interventions exist, there is likely to be some impact on the cost and benefits of innovation as perceived by private parties and, hence, some influence on the tendency towards underinvestment as predicted by the theory of externalities as simply expressed. In certain industries the net influence of current governmental actions may have been to accentuate the tendency towards underinvestment. In others, existing US Government policies, taken together, may have already overcompensated for any tendency towards underinvestment, so that programs designed to simulate the results that would be produced if externalities could be fully taken into account might well call for the institution of mechanisms designed to *discourage* additional private investment in technological change.

What is readily apparent is that the appropriate degree of compensation for any tendency to underinvest will vary widely by industry. This suggests that industry-specific programs are more likely to produce appropriate results than are programs applicable to all industries. Also implied is that a prerequisite to the intelligent formulation of science and technology policy by the US Government is a clearer understanding than currently exists of the net impact of the mass of regulatory, tax, patent, anti-trust, procurement, and trade policies (just to name the most obvious) on private incentives to invest in technological change. In most cases any such linkages that exist are currently only dimly perceived even by the agencies charged with administering the policies mentioned. They are all but unknown to those agencies charged with the formulation of US Government science and technology policy.

Some means must be found to correct this situation. Perhaps consideration should be given to requiring that US Government agencies charged with regulating various segments of the economy be required to produce "Technology Impact Statements", analogs of the Environmental Impact Statements that currently must be prepared to accompany their major policy decisions. Certainly it makes as much sense for the Interstate Commerce Commission, the agency charged with the regulation of US rail and motor carriers, to consider the effect of its rate and entry policies on the railroads' incentive to innovate as it does to consider the impact of these same policies on the environment*. Indeed, a major candidate for preparing Technology Impact

* An attempt to do just this is contained in the document *Improving Railroad Productivity; Final Report of the Task Force on Railroad Productivity*, A Report to the National Commission on Productivity and the Council of Economic Advisors (November 1973).

Statements would be the Environmental Protection Agency itself. Many of this agency's actions have a major (if currently unrecognized or unacknowledged) influence on the R & D decisions of many industries*.

Admittedly, it might prove administratively infeasible to require Technology Impact Statements even if only for major decisions. However, some means needs to be found to raise the "innovation consciousness" of the governmental agencies involved in direct and indirect regulation and to provide higher level decision makers with information about the current state of incentives so that any programs they propose to institute to correct "market failures" with regard to private investment in science and technology will be likely to produce appropriate results.

To illustrate the scope of such influence, I have compiled the following list of US Government policies which have a significant impact on the rate or direction of technological change in the commercial aircraft industry. By this choice I do not mean to contend that this industry is typical as far as the degree of US Government influence on its pattern of technological change is concerned. It is, in fact, perhaps the leading example of such influence. Its choice may be justified on the grounds that even in what is perhaps this most obvious of cases, the degree of this influence is not at all understood by the relevant decision makers, as certain policy proposals discussed below will illustrate. The list probably is not exhaustive. In particular, no attempt has been made to include these policies which have an impact on all industries such as the favourable tax treatment accorded to R & D expenditures. Finally, no quantitative attempt has been made to compare the level of technological change that actually exists in this industry with whatever externalities may exist, though some quantitative estimates of impacts would be a necessary part of technology impact statements, if they are to be useful.

—The US Government, through the National Advisory Committee on Aeronautics and its successor, the National Aeronautics and Space Administration, and through its military aircraft development programs, has paid for most, if not all, of the basic research and much of the applied research required by the commercial aircraft industry. The basic technological problem for the industry has been to choose among relatively known, and in some cases well proven, technologies and from these assemble a product that provides enough of an economic advantage over existing models to induce orders in a volume sufficient to justify production. In short, the risk has been primarily eco-

* See, for example, *Cumulative Regulatory Effects on the Cost of Automotive Transportation*, Final Report of the Ad Hoc Committee, prepared for the Office of Science and Technology (28 February 1972).

nomic, not technological. Only in the case of the SST was the industry attempting to push out the technological frontier with a commercial aircraft to any significant degree, and even here prior military developments such as the B-70 had answered many of the basic technological questions [6].

According to a recent study by Sydney Carroll, the US Government has permitted aircraft manufacturers to earn rates of return on total investment on military aircraft projects that have been substantially in excess of the level required to allow these firms to attract capital. This has permitted these manufacturers to initiate commercial aircraft projects whose prospective rate of return, adjusted for risk, has been below that which ordinarily would be required. This has led in turn to a greater number of new commercial aircraft projects and consequently, to more technological change [7].

The two policies just mentioned affect the supply side. Other important US Government policies have had a profound effect on the level, and more importantly, on the *timing* of the demand for commercial aircraft. And this 'market pull' has had its own substantial impact on the rate of technological change in the commercial aircraft industry*. Among such policies are the following:

—US Government subsidy to the trunk airlines during their early days of operation allowed them to purchase aircraft in quantities that made production of new aircraft types feasible. This was particularly important during the immediate post-World War Two period. US Government subsidy to the local service carriers at first supplied the carrier group with funds to buy used aircraft from the trunks. This demand drove up the prices of these used aircraft to above book levels generating capital gains for the trunklines providing them with an additional source of funds with which to purchase new aircraft. More importantly for the trunklines, the knowledge that the aircraft they were buying would not decline substantially in price reduced the risk to these carriers of over-ordering new aircraft.

—US Government subsidy to the local service carriers during the early and mid-1960's was essential to providing the profits that established the credit-

* The 'market pull' impact need not be always in the direction of stimulating increased investment in technological change. Leonard Lederman, in commenting on the original draft of this paper, has suggested that in cases when US Government stimulation of demand results in demand exceeding supply, innovation can carry with it the risk of disruption of the orderly flow of output and an attendant loss of current sales. One instance in which the drive to maximize current output resulting from excess demand has indeed appeared to have had a serious adverse impact on the incentive of the industrial enterprise to innovate in spite of relatively high long-term payoffs has been in Soviet industry [8]. The net impact of demand stimulation on private incentives to innovate must be judged on a case-by-case basis.

worthiness of these carriers enabling them to become major markets for short-haul new jet aircraft [9].

—Civil Aeronautics Board regulation of air carrier fares tends to discourage carriers finding themselves in an inferior equipment position from attempting to overcome this disadvantage by offering lower fares. This has tended to produce ‘bunching’ of aircraft orders, since when any one major carrier ordered a new aircraft type, there was substantial pressure for his competitors to follow. This ‘bunching’ of orders is crucial to the successful launching of a new transport program. William Jordan in his study of the equipment-buying strategies of unregulated California intrastate carriers has confirmed this impact of regulation on technological change in the commercial aircraft industry [10].

—The US Treasury has established extremely liberal depreciation policies for transport aircraft. The most recent Treasury guidelines allow such investments to be written off over a five-year period for tax purposes [11]. To the extent that air carriers actually keep aircraft for a period longer than five years—and in practice most do—this policy represents an interest free loan from the Treasury to the airlines which is translated at least in part into an increased demand for aircraft.

—The Export–Import Bank participates substantially in the financing of virtually all aircraft sold overseas. This participation is not limited to aircraft sold to underdeveloped countries. Airlines in Japan, Switzerland, Scandinavia, and The Netherlands have all received Eximbank assistance in financing recent wide-body jet acquisitions [12]. The availability of such financing can have a substantial impact on the demand for aircraft. The Aerospace Industries Association in a recent publication noted: “...the lower rate of interest made possible by Eximbank participation, plus the extended period of repayment allowed by the bank, can be quite significant to a buyer who must plan on covering all repayment costs with operating earnings. An annual cash flow reduction of as much as 25% below what would be required with straight conventional financing is possible.” [13].

This is indeed a formidable array of programs serving to correct any tendency that might exist for the commercial aircraft industry to underinvest in technological change due to its inability to capture fully the benefits this technological change creates for society*. In spite of this, a Presidential Commis-

* Certain programs or policies may have the opposite effect: (i) US Government regulation and subsidation of local service carriers has tended to discourage the development of aircraft designed to provide efficient service on short-haul, low-density routes. (See Eads [9] esp. pp. 125–142.) Exemption from economic regulation of a class of small

sion recently concluded that the United States can no longer rely on the free market to produce new transport aircraft in the quantity and variety required to meet the challenge of foreign competition. The Commission proposed the creation of an agency within the Department of Transportation that would decide when new aircraft types were 'required' and also the company that would build these new aircraft [14]. At about the same time the then-chairman of the Civil Aeronautics Board, Secor Browne, was touring the country raising the spectre that without substantial aid from the US Government, no more commercial aircraft would be produced in this country after the production of the current generation of aircraft is completed [15].

These two examples show how a theory that has substantial potential use as a guide to decision-making may be used to justify bad policy if no way exists to show that the policy being touted is, in fact, inappropriate. The theory of externalities in its simplest form predicts that under a certain set of assumptions there will be a general tendency for private industry to underinvest in technological change and states that governmental intervention aimed at correcting this tendency may be proper. The practical outcome is that someone—perhaps even a party having a substantial private financial interest in the outcome—perceives that an industry is achieving a rate of technological change below the level that the particular party believes is desirable. After suitable publicity has increased public awareness that a problem exists, a prestigious panel is thereupon convened. After an appropriate interval it produces a report stating that while, of course, everyone knows that the economy would operate best if the market were left free to operate, in the particular case at hand the market has 'failed' and cannot be trusted to bring about the socially desirable result. It is at this point that the theory of externalities is invoked. In the case at hand, the fact that no US commercial aircraft manufacturer is producing aircraft equivalent to the A-300, the Mercure, the VFW-614, the Yak 40, or the Concorde is taken as proof positive of market failure. No attempt is made to have a truly disinterested outside party determine whether the alleged market failure has indeed occurred and, if it has, to pinpoint the source of that failure so that a remedy designed to correct the problem with a minimum of interference in the operation of the

operators has tended to have the opposite effect. (ii) In 1928 the Manufacturers Aircraft Association, Inc. (MAA), a group consisting of most major aircraft manufacturers, entered into a patent cross licensing agreement at the urging of the government. In 1972 the US Justice Department filed an antitrust suit against the MAA charging that the agreement amounted to a device to eliminate competition in research and development and had retarded innovation in the aircraft industry. (US Justice Department press release, 29 March 1972.)

market can be fashioned. Again referring to the case at hand, it apparently never occurred to the Presidential Advisory Commission or to Mr. Browne that the failure of the US commercial aircraft industry to produce analogs to the aircraft mentioned is perhaps a signal that the market is indeed working properly. In this industry—as in most others—supply does not create its own demand. I have been unable to locate a single case where a promising commercial aircraft was not produced due to the failure of the market properly to rate its commercial prospects, but I have uncovered many cases in which aircraft were produced after having been given massive direct governmental aid on the grounds of market imperfections and in which the pessimistic judgment of the market has been fully vindicated. Indeed, the entire postwar British experience can be viewed in this light.

Thus far attention has been confined to problems raised by the fact that conditions in industry do not generally correspond to those that must exist if the simple theory of externalities is to provide an unambiguous guide to the appropriate level of US Government intervention in the process of technological change. We turn now to the dangers that may exist if a premature attempt is made to put US Government science and technology policy on what might appear at first to be an economically more rational basis.

There has been much concern expressed by the scientific community that the fiscal 1974 budget implied a downgrading of basic science in favor of applied research. Science policy was said to have come “under the reign of economic decision-makers.”*. William O. Baker, president of Bell Labs and head of the recently created Science and Engineering Council, stated: “The Administration is anxious to apply to government more of the values of the business community—efficiency, cost-effectiveness, chains of authority.” [17]. The thrust of the fiscal 1974 budget was said to have been toward “maximizing short-term payoff in research” in energy, health, and transportation—areas deemed to be of “special national concern.” [18].

It is difficult to short out the rhetoric from the reality to learn just how significant any such policy ‘shift’ was**. If history is any guide, at least some of what was publicly called a ‘shift’ merely represented the repackaging of existing programs so that they appeared to be more in line with current domestic political concerns. Yet the highlighting, even if only with rhetoric, of the desire to make US Government science and technology policy more ‘businesslike’ raises a valid concern over what is likely to be the result.

* “It’s Austerity Time for Basic Science” [16]. The subhead of this article states: “The academicians are out. And so is the emphasis on backing basic research”.

** For a view that the concern over the “shift” is overstated, see Wade [19].

One prediction that comes out of the simple version of the theory of externalities is that the degree of underinvestment by private industry—and hence the size of the proper role for government—is greater the closer one gets to the basic research end of the technological change spectrum. As the President's Council of Economic Advisors notes in the passage quoted earlier, this is because the returns to basic research are unlikely to be fully perceived at the time the research is being carried out, are even less likely to be fully capturable by the funding party, and are likely to be realized only in the distant future. The further toward applied research and product development one proceeds, the more likely it will be that the person funding the research will be able to perceive and capture fully the total social benefits resulting from his outlay, and hence, the less likely it will be that there will be an underinvestment in technological change.

All of us, and most particularly we economists, favor allocating our scarce resources where they will bring the greatest return to society. And it certainly is possible that in our desire to see that science not go undernourished we have instead overfed it so that some slimming down of unpromising programs is justified. But how should an evaluation as to whether such a 'slimming down' is needed be conducted? *If* economists currently were able to measure externalities, this could be done relatively easily. The net social rate of return (the social rate of return minus the private rate of return) to funding additional research in basic mathematics, physics, biology, or astronomy could be compared to the net social rate of return from additional government aid for the development of 'people movers', quiet jet engines, or breeder reactors. Scarce governmental funds could then be distributed so as to maximize their contribution to society's well-being.

The process just outlined reveals the problem. As of today, economist *cannot* routinely measure externalities. The necessary tools have not been developed. Therefore, to allocate US Government funds on the basis of demonstrated potential economic payoff is bound to lead to an underfunding of basic research by the government for one of the same reasons that business itself underfunds basic research—because its economic benefits cannot be fully perceived.

This unfortunate tendency is likely to be accentuated by the fact that the payoff to the government from support for applied research may be overestimated. For reasons that have already been mentioned, supporters of funding for basic research are often unable to point to any specific economic benefits that will flow from their projects. Supporters of applied research, however, usually can point not only to tangible goods or services which will exist if their projects are funded and are successful. They can also point to 'second-

ary' benefits that the production of these goods or services will create—employment and exports, for example. It does little good to point out that in a majority of cases, these 'secondary' benefits can be shown, if subjected to disinterested critical analysis, to be at least overstated and sometimes to be entirely spurious. Their claimed existence, and particularly the fact that they can be stated in dollar magnitudes, lends a powerful additional appeal to the projects they are associated with. Furthermore, even the direct benefits of governmental support of applied research lend themselves to overstatement. In many cases government aid merely acts to speed up the availability of some new technology. However, supporters of government funding for such projects invariably credit government support with bringing the technology into existence rather than properly counting only those additional benefits that would accrue to society from having this technology available sooner rather than later.

Therefore, it is possible that if government support for science and technology truly were put on a more 'businesslike' basis before the tools exist that will allow the full social benefits of research to be measured, basic research might be underfunded to a *larger* degree than it would be if its support were left entirely to private industry. This is not to suggest that this outcome will be likely. Despite rhetoric about shifting US Government R & D funding from a 'supply-push' to a 'demand-pull' orientation, it is to be expected that most of the actual decisions concerning basic research support will continue to be made (and appropriately so, given the current state of knowledge) on the basis of rough rule-of-thumb calculations about what proportion of the nation's resources it can 'afford' to devote to basic research.

However, the distortion that a premature 'rationalization' of US Government support for science and technology might introduce would not be limited to basic research. Applied research projects differ in the real (or claimed) externalities they may generate. It is predictable that once the simple form of the theory of externalities is communicated to and understood by the science and technology community, it will be increasingly misused as interested advocates vie with each other to uncover 'benefits' now being lost to the nation because the program they are supporting does not now exist. The extreme difficulty of measuring externalities, exemplified by the problem of measuring the benefits of basic research alluded to earlier, will contribute to this tendency. If care is not taken, 'externalities' will be discovered primarily where it is politically advantageous to discover them*.

* I do not mean to fault the science and technology community for doing this. They will

As noted earlier, a good deal of the responsibility for this state of affairs, and much responsibility for seeing that it does not happen, rests with the economics profession. Too often, as in the case here, economists have discovered an economic principle, have publicized it and achieved its acceptance, and then have forgotten about seeing to its proper implementation [20]. This can be attributed in part to the current reward structure in the profession. The most prestige is accorded to developing new theory. Less prestige is attached to a skillful job of publicizing a theory and securing its acceptance. Little or no prestige attaches to performing the difficult work of making the theory operational. Yet if economics is to continue to be useful as a policy science, some way must be found to assure the quality of the product once it has passed out of the realm of the economics journals and into daily practice. Economists must take a greater interest in translating abstract economic concepts like externalities into language that policy makers can understand. They must explain clearly how externalities can be recognized, and, perhaps more importantly, what externalities are *not* as well as what they are. They must carefully communicate their assumptions and provide the tools that will allow the policy makers to discern how well these assumptions are realized and in what directions the policy implications of the simplified theory are altered if these assumptions are not fully met. Second, some method needs to be found, such as was done in the case of the US SST project to 'blow the whistle' when the misuse of basic economic concepts becomes gross. Perhaps Dr. Alan Ferguson's new Public Interest Economics Center is a prototype of such an institution [21]. But to retain credibility such an institution must be careful to avoid the lure of partisanship. Whistles must be blown when economic concepts are misused to justify programs that are highly popular to the person blowing the whistle as well as when such concepts are being used to bolster programs the 'whistle blower' personally finds distasteful. This is the essence of professionalism.

A final observation. When considering the replacement of the judgment of markets with the judgment of men—such as has been proposed in the commercial aircraft industry—a full understanding of the past history of such attempts must be kept in mind. Markets are undoubtedly imperfect, but bureaucracies also suffer from major imperfections. The relevant comparison, therefore, is between the results that will likely be produced by two highly imperfect systems.

be following a well-trodden pathway. Water resource development and urban renewal are but two examples of programs where US Government funding was justified largely on the basis of 'externalities' but where the externalities have, in retrospect, proved to be largely illusory.

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Statement by

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Prepared for

Subcommittee on Aviation and Transportation R&D

Committee on Science and Technology

U. S. House of Representatives

May 7, 1976

AIRSPACE: AN UNTAPPED TRANSPORTATION MEDIUM

My name is Glen A. Gilbert, an independent aviation consultant for over 25 years, specializing in programs for increasing air transportation safety and efficiency, including such areas as aircraft operations, air navigation, airport design, air traffic control system engineering, and many related facets in the field of research and development.

We frequently hear the phrase "the crowded sky". I use the term "the uncrowded sky"! I say this because it is not the airspace as such that is crowded, but rather it is the Air Traffic Control System that may be considered to be crowded or overloaded in certain circumstances.

The System

When I refer to the ATC System in this context, I include the following elements:

aircraft

airports

navigation and communication services

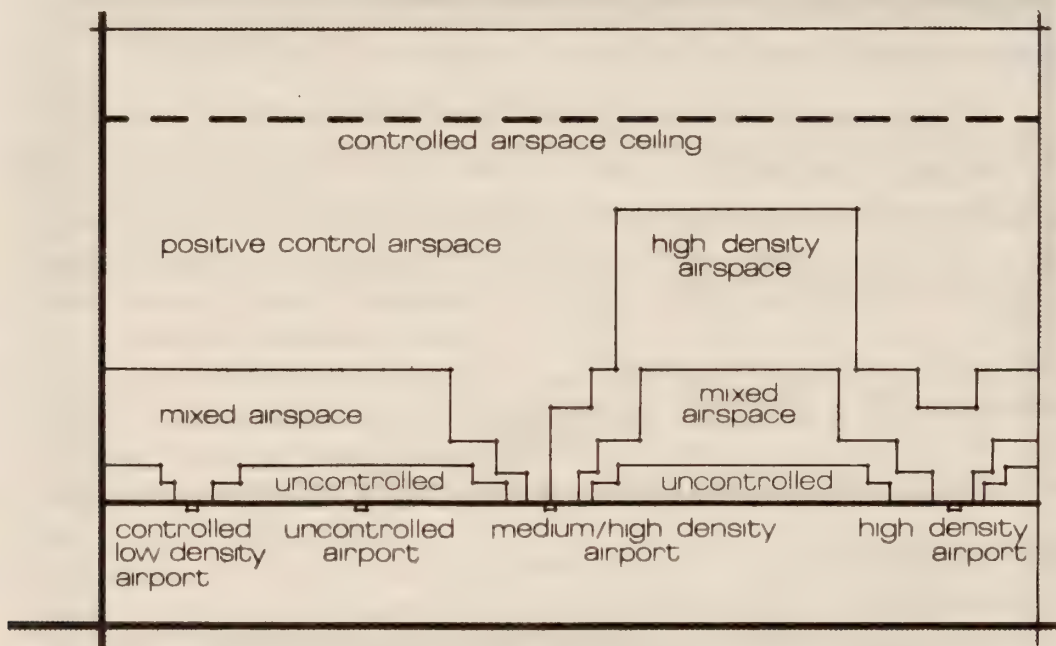
airborne and ground equipment

weather services

rules, regulations and procedures

controllers and pilots.

The controllers and the pilots form the team that makes the whole system work. But their performance is directly affected by the other elements comprising the system. The single most significant element affecting the productivity of the controller/pilot team, and in turn the use of the airspace as a transportation medium, is aircraft. The aircraft -- CTOL (conventional takeoff and landing), STOL (short takeoff and landing), and VTOL (vertical takeoff and landing) -- in turn impact the second most significant element affecting system capacity -- airports. Aircraft and airports thus form the basis on which our entire Air Traffic Control System is founded, affecting all the other system elements such as ground and airborne equipment requirements, communications and weather services, air traffic control separation procedures, airspace structuring, and so on.



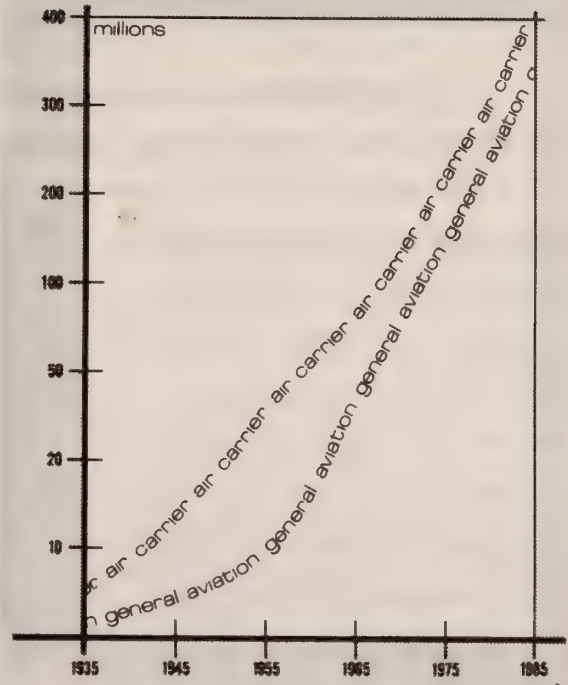
Simplified model of airspace structuring.

Demand/Capacity

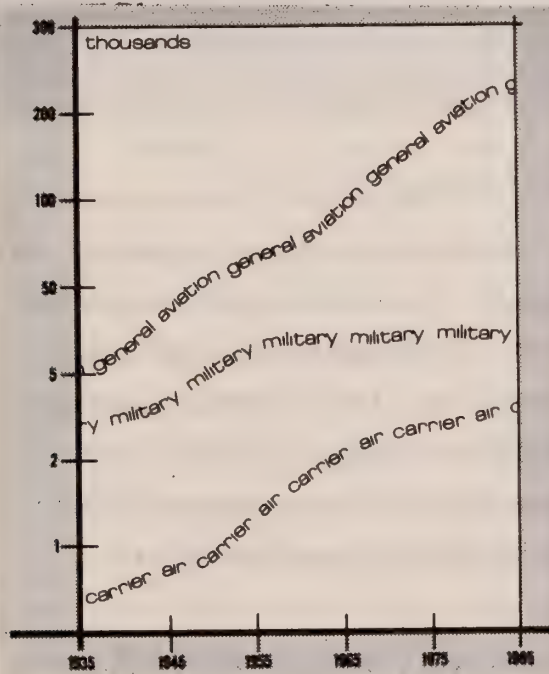
At this point I would like to touch on the matter of air transportation demand as related to airport capacity. Again assuming that our national

economy will progress normally, forecasts indicate that by 1985 the country's airlines will need to carry around 400 million passengers and general aviation will be carrying close to the same number. By then the general aviation fleet will have increased to well over 200,000 aircraft, and the airline fleet will have increased to about 3,500 aircraft.

Looking at the airline passenger growth another way, by 1985 the scheduled air carriers will have to handle one



Comparison of passengers carried by air carriers and general aviation.

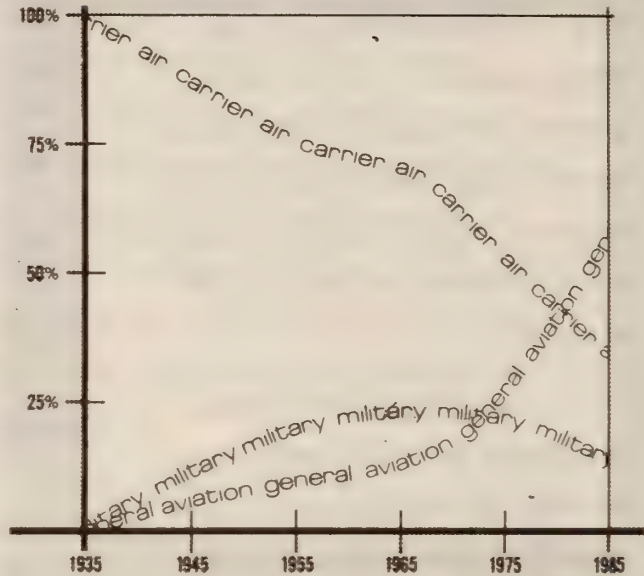


Numbers of aircraft by airspace user.

billion enplanements and deplanements annually. By 2000, the air carriers will be called on to carry some 2.7 billion enplanements and deplanements annually. In other words, during the next 8 - 10 years we are anticipating about a three-fold increase in airline passenger volume, and by the end of this Century something in the order of a seven-fold increase. General aviation passenger handling will be increasing

proportionately, with instrument approach activity exceeding airline instrument approaches by about 1980.

In considering the impact of air transportation demand on airport capacity, it is significant to note that, although there are in the order of 4,000 airports in this country capable of accomodating some degree of scheduled air service, about 40% of the total air carrier enplanements take place at 10 airports (Chicago O'Hare, Los Angeles International, JFK International, Atlanta, San Francisco International, La Guardia, Dallas/Ft. Worth, Washington National, Miami International, Boston.); around 70% at 30 airports, and 85% at 60 airports.



Percentage distribution of instrument approaches by class of airspace users.

What happens at these relatively few airports directly affects the efficiency of the Nation's entire air transportation system for both air carriers and general aviation. As any of these airports becomes "saturated", the FAA may impose quotas limiting the airport's use. If delays start building up at a key hub airport due to congestion, the impact is felt across the country by limiting departure of all classes of air traffic from other airports to the major airport concerned. For example, witness the nationwide chain-effect caused by a recent closing of two runways at O'Hare for resurfacing.

In its introduction to the National Airport System Plans (NASP), the FAA points out that the National Aviation System comprises a number

of closely interrelated sub-systems of which the airport "is a critical element as the terminus for all flying activity". The statement goes on to say that "Increases in the air traffic control system may be of little value in some locations if the airport continues to be a bottleneck".



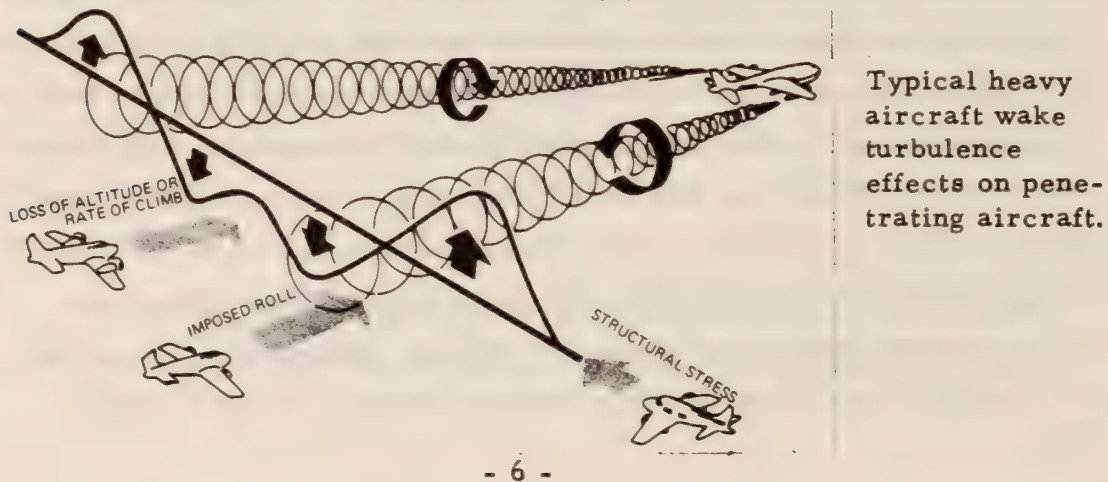
Example of a typical "airport bottleneck" effect on departing aircraft a few years ago.

During the past two or three years, it may have appeared that the problem of the "airport bottleneck" had about disappeared in the light of reduced air traffic delay statistics published by the FAA. However, this was illusory in the sense that the entry of the wide bodied jets into the airline system resulted in greater capacity with less aircraft operations. To illustrate, based on the 1969 average airline aircraft passenger capacity, about a 30% increase in aircraft movements would have been required by 1972 without the introduction of the jumbo jets. This factor is a major reason why air transportation has been able to develop in the years since 1969 without noticeable strain on the Air Traffic Control System and essentially without a serious airport

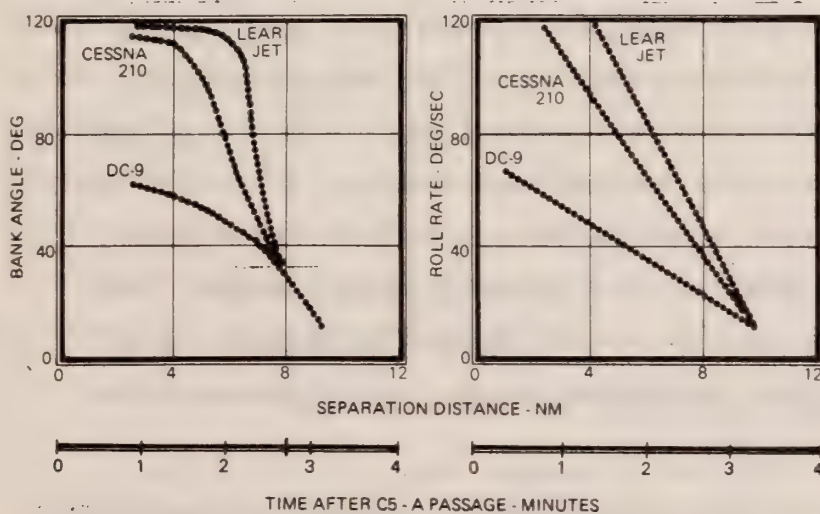
capacity problem.

However, looking to the future, the wide bodied jets will at some point reach a saturation level in terms of today's conventional airport capacity criteria. It might be suggested that a solution is to further increase the size of aircraft from the B-747's 800,000 lbs. to say 2,000,000 lbs. An aircraft in this category would require such facilities as wider and thicker runways, greater turning areas, and double decked terminals. In short, to accomodate a generation of super jumbos, today's airports would have to be completely rebuilt, not a likely feasible solution to meet future air transportation demand. Furthermore, the economics of scheduled air transportation experience in recent years have shown that frequency of service is very important, as evidenced by the continued production of DC-9/B-727 types and the diminishing production of B-747/DC-10/L-1011 types.

Thus there is no doubt but what the "airport bottleneck" will again rear its ugly head. The question is when? The Aviation Advisory Commission in its final report in 1972 observed that saturation in the top 30 air carrier airports (handling 70% of total airline traffic) had already commenced with some, and that it would continue progressively with all during the 1970's and 1980's, reaching complete saturation within 20 years unless remedial measures are taken. Should the wake turbulence problem not be alleviated, the report points out, saturation of these key airports may occur at an even more rapid rate than projected.



It is well understood that wake turbulence is a very significant factor adversely affecting airport capacity. Before the advent of the "heavy" jets (gross weight 3000,000 lbs. and over), standard ATC separation between aircraft in-trail was 3 miles or slightly less giving a runway acceptance or departure rate of about one aircraft per minute. Now, however, separation behind heavy jets is not less than 5 miles or two minutes, resulting in a runway acceptance or departure rate of one aircraft at about 2 minute intervals. Thus, while increasing aircraft capacity has been accomplished on the one hand, we have reduced airport capacity on the other.



Roll reaction of light aircraft to heavy aircraft wake turbulence.

Solution to the wake turbulence problem involves reducing its effects through developments in ground dissipation devices together with dissipating airborne devices and/or airframe modifications. In addition, ground

sensors are needed at airports to detect, measure and monitor wake turbulence conditions for input to the controller. Developments along these lines are well underway by both FAA and NASA, and I believe that it is reasonable to anticipate some diminution in the adverse effect of wake turbulence on airport capacity in the next couple of years. It does not appear though, that the adverse effect of wake turbulence by heavy jets on airport capacity can be entirely eliminated.

To keep up with air transportation demand, basic approaches must

be made to provide new airports where feasible, increase capacity of existing airports, and apply new air vehicle technology, if we are to use most effectively the infinite capacity of the airspace as a transportation medium.

New Airports

With respect to the provision of new conventional airports, I think that with the completion of the Kansas City and Dallas/Ft. Worth airports, we will see very few, if any, major new conventional (CTOL) jetports constructed in this country for the remainder of this Century. Land availability is the first hurdle to overcome in considering a major new jetport. How many new airport developers can find an 18,000 acre site (larger than Manhattan Island!) to equal Dallas/Ft. Worth? Miami thought they had found one in the Everglades a couple of years ago, but it was finally vetoed because of environmental reasons. A more recent 50 square mile site selected in the remote northwest corner of Dade County has come under fire because of possible "water damage". New York appears to have given up the search, at least for the time being. The Los Angeles (Palmdale) project has run into trouble because of environmental reasons. And so it goes.

Even though a site may be found which is deemed technically and economically suitable, environmental considerations may rule it out. The National Environmental Policy Act (NEPA) and ADAP, under the Airport/Airway Development Act, together call for a number of time consuming and complex actions to be carried out before a new airport site can be approved. Involved is a full environmental impact review in coordination with federal, state and local agencies as well as the public, covering such factors as potential disruptive effects on the community, including noise, infringement upon parks, recreation areas, wildlife refuges, and compliance with applicable state water and air quality standards.

Although land availability and environmental impact are the two leading factors affecting the provision of a new airport, funding also is a factor which can be of significant proportions particularly in the case of a major jetport. In today's market, \$1 Billion is probably the minimum needed to get this type of project underway. Additional funding will need to be anticipated for future expansion, and large expenditures will be required of the airlines and other airport tenants.

In summary, the probability of providing new jetports to meet the forecast future air transportation demand in the Large and Medium hub areas in particular appears to be highly unlikely. Even in the case of Small and Non-hubs as well as reliever and other general aviation airports, the same land availability and environmental limitations will apply, although the magnitude of the problem of providing new airports in these categories generally will be somewhat less. Thus, in order to more effectively solve the demand/capacity problem, exhaustive attention must be given to increasing the capacity of existing airports, as well as to using new technology air vehicles.

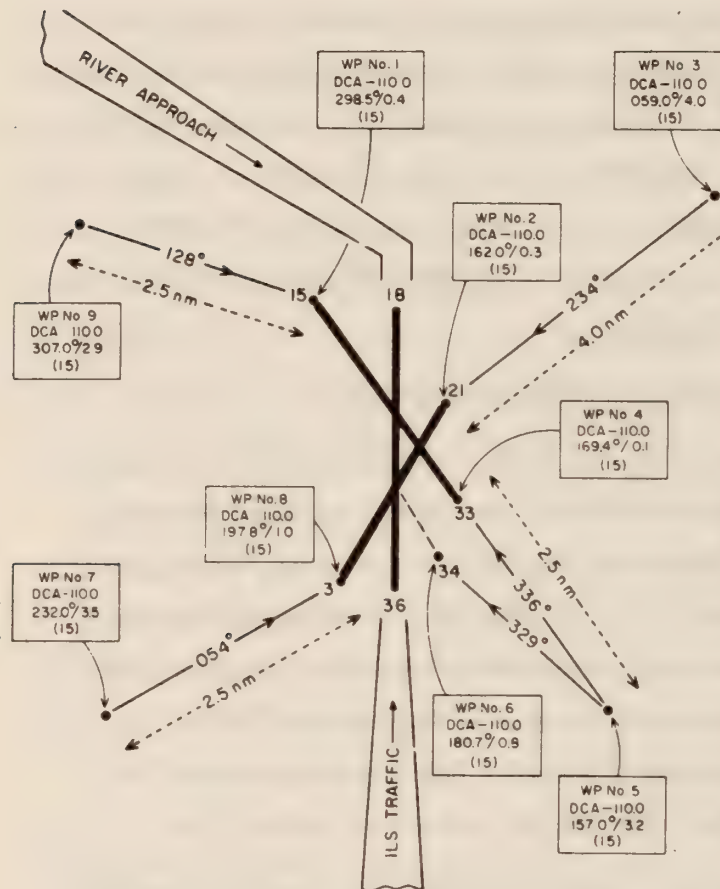
Increasing Existing Airport Capacity

Fundamental to airport capacity is the "productivity" of each runway comprising the total airport system. The basic standard for determining runway utilization applicable to CTOL aircraft is the principle that an arriving aircraft should not be committed for a landing and that a departing aircraft should not commence takeoff until a preceding aircraft has turned off the runway or is completely airborne. Thus, the ability of landing aircraft to vacate the active portion of a runway rapidly is a factor which directly affects the runway's productivity.

In a recent MITRE report "Models for Runway Capacity Analysis", prepared for the FAA, runway occupancy time was considered from touchdown to roll-out at runway exit. Variables included aircraft weight, stall speed, runway condition (wet or dry), exit location and design speed, and braking capacity. As an example, the model showed that for an

aircraft having an approach speed of 135 knots, occupancy time would average about 36 seconds in a high speed turn-off at 30 knots, and 44 seconds in a zero speed turn-off.

In other words, the theoretical productivity of a CTOL runway (with relatively common-speed aircraft) could be somewhere between 80 and 100 movements per hour. In actual practice today, runway utilization even at the busiest conventional jetports averages no more than 40 - 45 movements per hour in IFR conditions, or about 50% of theoretical maximum runway productivity which generally can be approached in VFR conditions.



Use of secondary runways (Washington National Airport) for RNAV instrument approaches independently of ILS approaches.

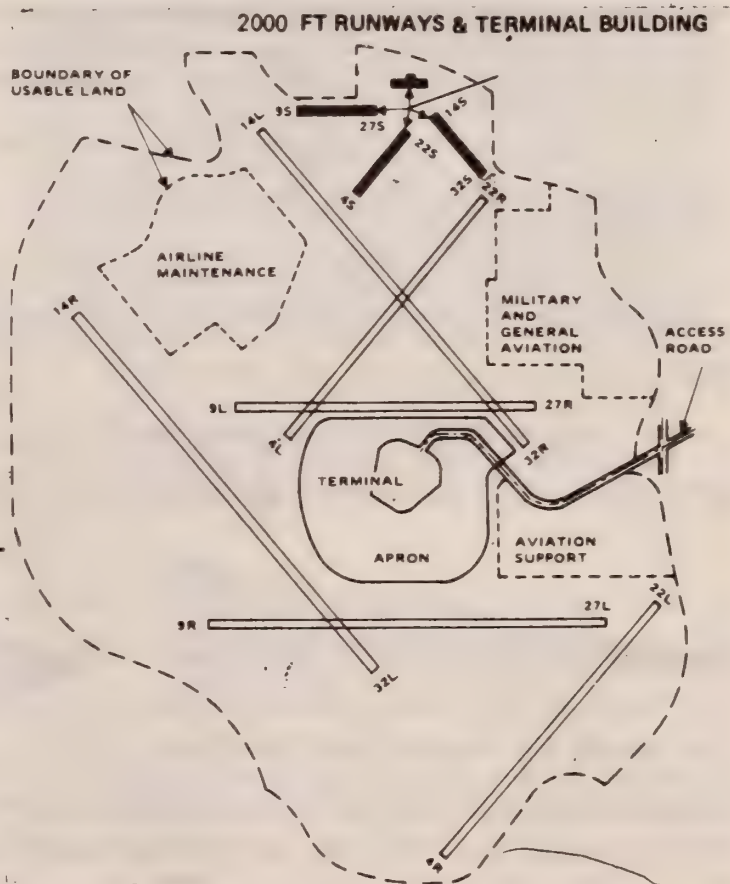
closer than 5000') in IFR; ability to have closer longitudinal and lateral

Obviously, an important aspect related to increasing airport productivity would be to bring its IFR capacity up that possible during VFR. Involved are such factors as ability to use intersecting or converging runways simultaneously in VFR, whereas only one "instrument" runway is used in IFR. (ability to apply airborne area navigation - RNAV - techniques can help achieve this objective); capability to use parallel runways simultaneously in VFR but only one (if spaced

spacing during VFR between arriving aircraft and between arriving/departing aircraft than is the case during IFR due to the stricter application of radar separation criteria by ATC. As an example, under VFR weather and favorable wind conditions, the existing JFK airport can handle over 100 operations per hour; however, a change to an unfavorable wind and IFR weather can reduce the airport's capacity to about 50 operations per hour.

Thus, the "name of the game" to better utilize existing airports is to raise both runway productivity and total airport capacity to equal or approach theoretical capacity goals under all weather conditions. Although many elements are involved in meeting these objectives, expenditures along these lines could be much more cost effective than equivalent money spent on new complementary airports. An action program to increase the CTOL aircraft capacity of existing airports can include:

- Improving runway/taxiway design and layout so as to permit minimum runway occupancy time.
- Segregating different classes of aircraft by performance characteristics (i. e., separate runways for high-performance and non high-performance aircraft.
- Providing parallel runways more closely spaced than the

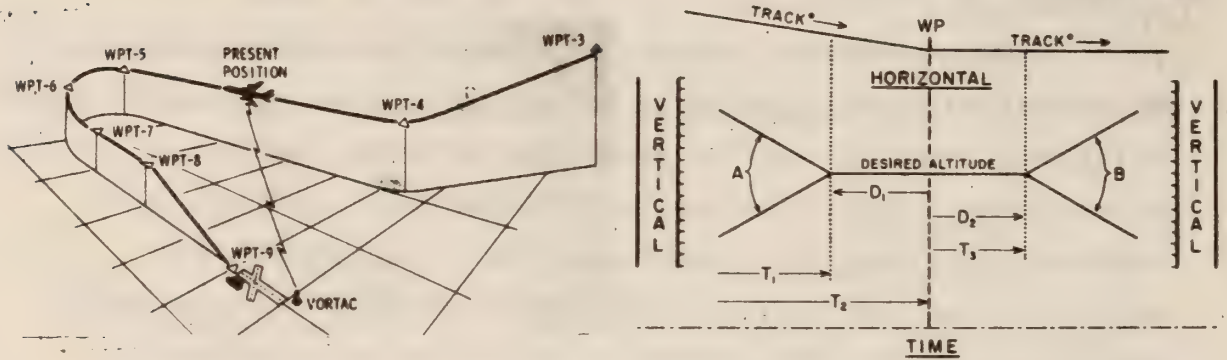


Creating separate STOLport and/or general aviation runways on a major CTOL airport

- 11 -

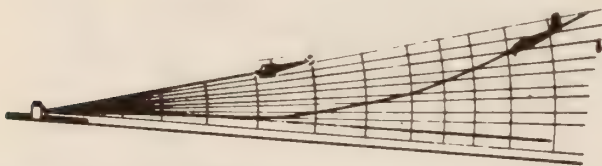
present minimum of 5,000'.

- Allocating to another airport that portion of short haul air services which is not of a connecting nature.
- Developing reliever airports as appropriate for general aviation.

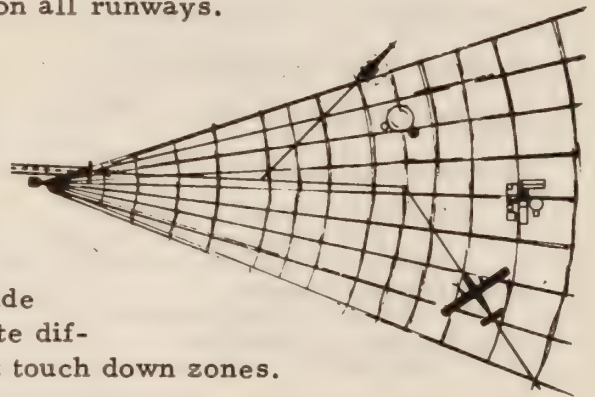


Area navigation (RNAV) 3-D profile based on VORTAC input. Adding time reference produces a 4-D profile in which pilot lands at desired point at desired time.

- Applying ATC metering and spacing techniques to maximize efficiency of traffic flow in the terminal area.
- Applying 4-D (time referenced) area navigation to achieve a consistently high degree of accuracy in delivering aircraft to runway threshold at the optimum time intervals.
- Providing the necessary approach and landing aids as appropriate to achieve all weather operation on all runways.



Microwave Landing System (MLS) has capability to provide pilot-selectable glide slope and approach path to help segregate different categories of aircraft to different touch down zones.



- Providing airport surface guidance (for pilot) and surveillance (for controller) facilities to permit use of the entire airport surface system with safety and efficiency under all weather conditions.

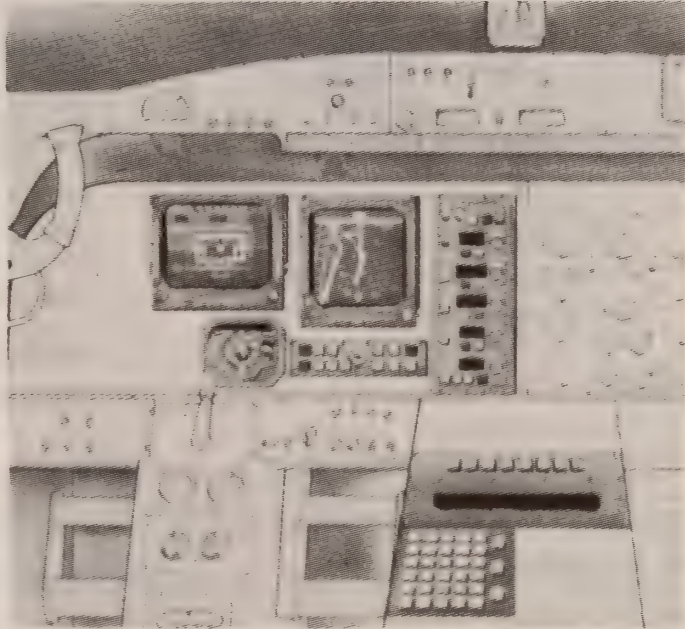
- Developing noise reduction techniques and procedures which do not adversely affect airport capacity.

- Providing advanced ATC equipment and procedures capable of handling high density terminal area and airport traffic of the magnitude visualized, including use of airborne area navigation and air traffic situation displays.

- Providing the additional passenger/cargo and ingress/egress capacity to match the airport's increased air traffic operational capacity.

The foregoing action plan merely touches on concepts which can lead to a significant increase in existing airport capacity. While the NEPA/ADAP environmental considerations will apply to such airport improvements

as the provision of a new runway, the clearance process is not as severe as in the case of a completely new airport; also, many of the items in the action plan do not involve NEPA/ADAP criteria. Obviously, however, increasing the capacity of an existing airport for CTOL traffic inevitably will reach finite limits. But a way to ensure that the Nation's total transportation demand



New cockpit CRT displays can supply the pilot with information on other traffic as well as providing independent landing monitoring assistance.

can be met, utilizing more effectively the infinite capacity of the air-space as a transportation medium, is through the application of new technology air vehicles.

New Technology Air Vehicles

New technology air vehicles which can contribute effectively to the airport capacity/air transportation demand goals are the V/STOL



Advanced Military STOL Transport (AMST) is being developed with future civil application in mind.

aircraft. Within this family are the RTOL (reduced takeoff and landing) aircraft requiring a runway length in the order of 4,500 to 3,000 feet; the STOL (short takeoff and landing) using 3,000 to 1,500 feet; and the VTOL (vertical takeoff and landing) capable of operating from an

area having dimensions of as little as just a few square feet.

It is obvious that as the size of runway/airport requirements is reduced, the problem of finding landing/takeoff sites is correspondingly reduced, the cost becomes less, and the environmental impact has a more constrained exposure.

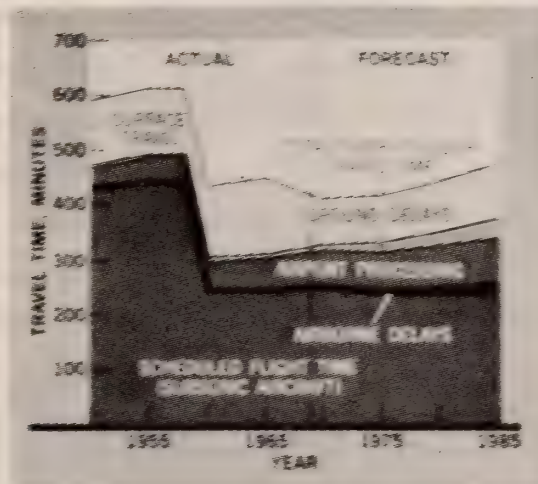
The extensive use of V/STOL's in short haul (under 500 miles)

city-city and intraurban services will result in more and more people becoming accustomed to routing flying. As a consequence, the aircraft would -- I believe -- take on the image to the general public of a



Helicopter landing on heliport in city-center environment.

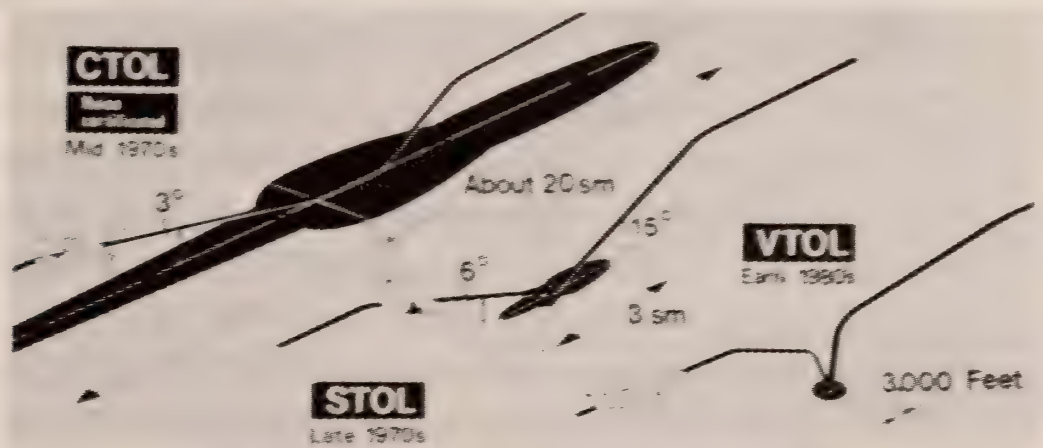
necessity rather than a "jetset" luxury, and public environmental acceptance of air transportation could thus be greatly facilitated.



Total door-to-door travel time between 1960 and 1985 remains about the same in scheduled airline service, even with the advent of subsonic jet aircraft. VTOL city-center to city-center service can cut total door-to-door time about in half.

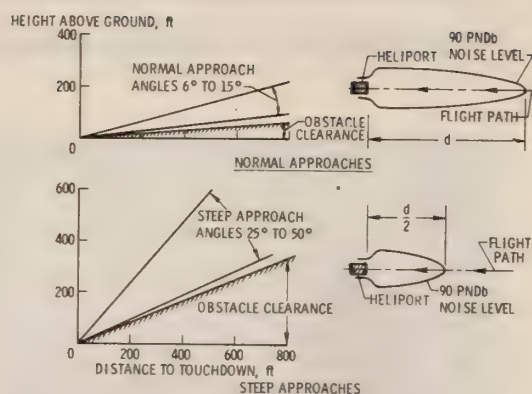
footprint even smaller than that of the STOL and RTOL, not to mention that of the CTOL.

Noise -- the number one environmental problem, is susceptible of solution more readily by V/STOL's than by CTOL's. In a recent short haul symposium sponsored by MITRE, it was stated that "the goal for STOL aircraft of 85 PNDB plus the steep, curved approach and takeoff patterns possible with STOL technology could reduce aircraft noise impact below that of ground traffic". Because of its minimal landing area requirements and vertical ascent/descent capability, the VTOL has the inherent capability of a noise

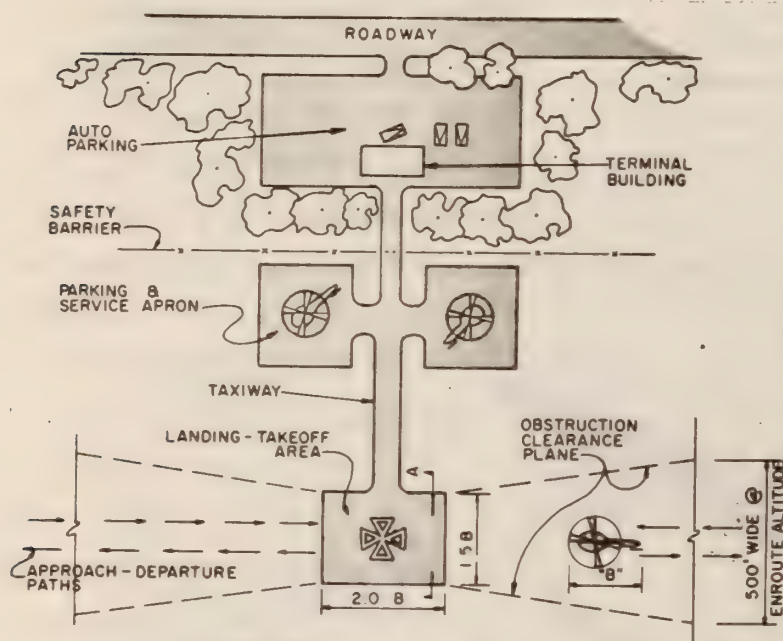


Comparative 90 EPNDB noise footprints.

In its policy study, the joint DOT-NASA Civil Aviation Research & Development (CARD) group said that "although expansion of existing airports could provide much of the needed short term gains, longer term capacity growth must be based on distributing traffic to additional landing sites". The study went on to recommend the development and evaluation of new concepts for airports (e.g., special purpose cargo airports, off-shore airports, STOLports and VTOLports), and "the development of a separate short haul system that would relieve CTOL facilities at high density airports by providing much smaller, less



With variable approach gradients, helicopters have capability to greatly reduce noise footprints where required.



Commercial type heliport for city-center application requires far less land area than STOLports or CTOLports.

expensive facilities closer to the demand for short haul service".

The NASP report also recognizes the potential importance of V/STOL's in providing expanded capacity to meet increasing air transportation demand. Says the FAA "the future introduction of Vertical and Short Take Off and Landing Aircraft may eventually have a significant impact on airport

system development". Also that the FAA "will continue to investigate and assess the feasibility of V/STOL operations in the National Aviation System".

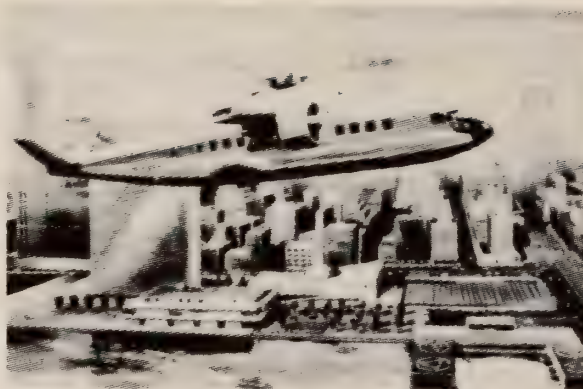
With the virtually unlimited potential of V/STOL's to increase air transportation capability and in turn help unload the CTOL airport bottleneck, it is timely to consider where this new technology now stands. The helicopter is the most viable member of the V/STOL family. Today it is being used extensively in servicing energy development off-shore and in remote areas; in corporate/business applications; in commuter operations and in many other applications. But to achieve optimum utilization, the helicopter needs to have virtually "all weather" (IFR) capability.



Bell 301 tilt-rotor advanced technology vehicle operates in helicopter mode below about 110 kts, and in airplane mode for cruising speed in the order of 300 knots.

Although the military services, particularly the Army, have been conducting IFR helicopter operations to a certain extent for some time, it has been only recently that civil IFR helicopter operations have begun to get underway in earnest. Currently, more and more helicopter manufacturers are turning out civil helicopters right off the production line that are fully IFR certificated in accordance with the Federal Aviation Regulations. In addition, a number of varieties of retrofit kits are now available to obtain FAA IFR certification of helicopters originally certificated for VFR only.

By 1980, the Helicopter Association of America estimates that there will be about 5,000 IFR capable helicopters, out of a total of some 10,000 in the combined U. S. /Canadian civil helicopter fleet. So we can now see the imminent advent of a very significant new IFR user of the National Airspace System.



Sikorsky S-65C-200 is an advanced concept for commercial use under current study.

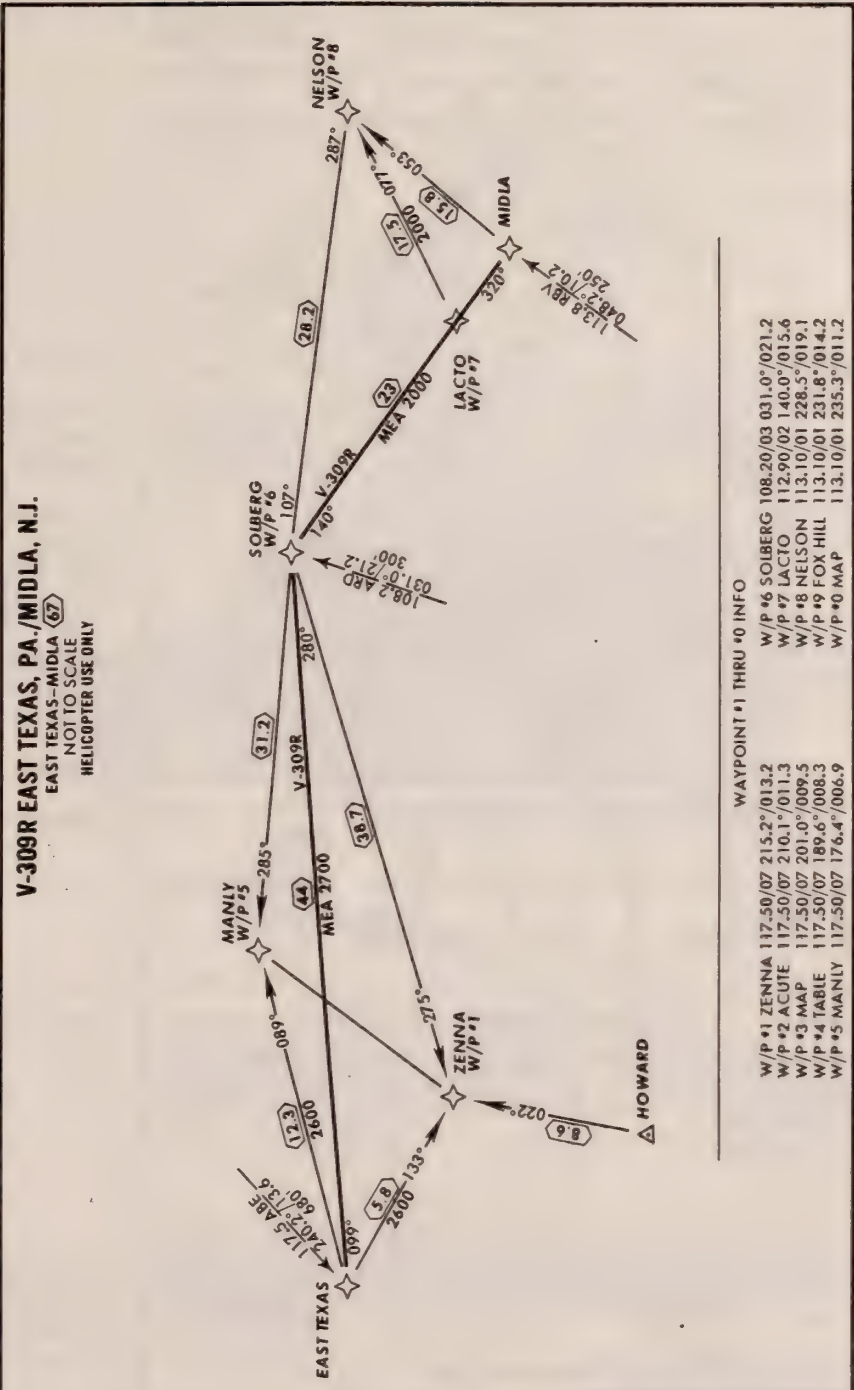
But what are some of the considerations and problems that need to be faced in order to achieve optimum efficiency in the operation of IFR helicopters in the National Airspace System? These are many and varied according to the IFR operation contemplated.

Essentially these directly involve interface aspects with the Air Traffic Control System. In a low density traffic area, flying IFR on a Victor airway and making an instrument approach established for CTOL aircraft poses no particular problem for the pilot or the controller. But, it should be kept in mind that, in such an environment, the helicopter will be treated by ATC as a fixed wing, CTOL aircraft. Its unique characteristics and capabilities as a Vertical Take Off and Landing vehicle are not being utilized to the advantage of either the pilot or the controller. The pilot might just as well be flying a fixed wing aircraft.

On the other hand, taking advantage of the unique characteristics of an IFR helicopter greatly increases utilization of the airspace, reduces both controller and pilot workload, and provides a new dimension in mass transportation potential. A dynamic pilot IFR helicopter project currently is underway to demonstrate this concept in the Northeast Corridor between Washington-New York-Boston with intermediate feeders along the lines visualized by the CAB in its "Northeast Corridor V/STOL Investigation" of 1970.

Mack Trucks, Inc.

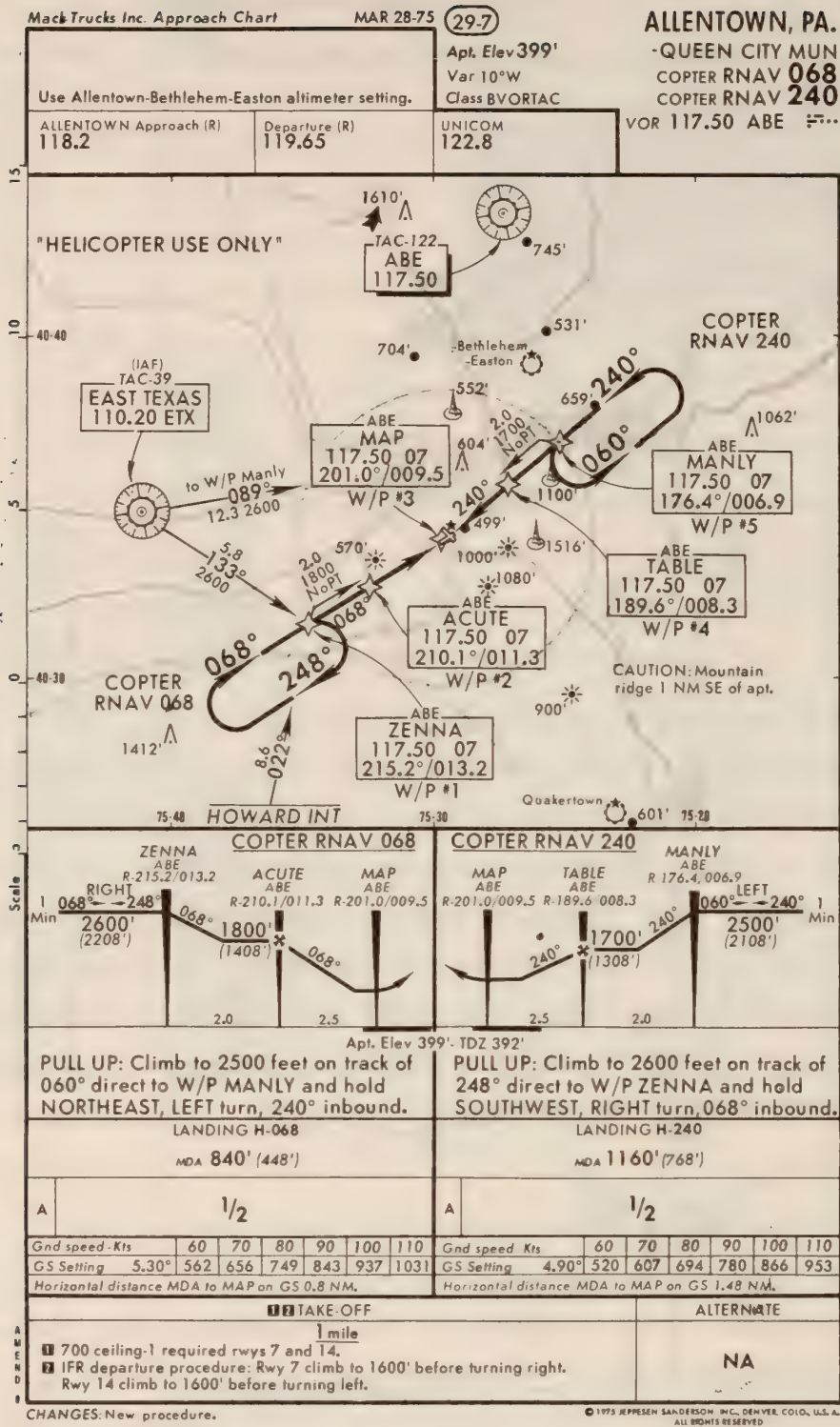
PAGE 1



CHANGES: New chart.

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Enroute discrete RNAV route structure for Mack Trucks'
IFR helicopter operation between Allentown and New York
Heliport.



Two RNAV instrument approach procedures for Mack Trucks' IFR helicopter operation to Queen City Airport (PA)

LaGuardia ATIS

Arrival	113.1	125.95
Departure	125.95	

Apt. Elev 7'
Var 12° W

DOWNTOWN-MANHATTAN HELIPORT

COPTER RNAV 039

VOR 113.10 LGA

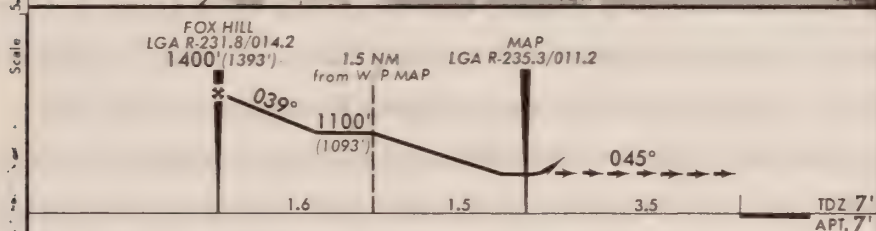
LA GUARDIA Approach (R) & Departure (R)

UNICOM
123.05

Class VOR DME



RNAV instru-
ment approach
procedure for
Mack Trucks'
IFR helicopter
operation to
Wall Street
Heliport.



PULL UP: Climbing RIGHT turn to 1700 feet direct to W/P FOX HILL and hold SOUTHWEST.

	I LANDING H-039 MDA 540' (533')	I TAKE-OFF	ALTERNATE
A	1/2	500ceiling-1	NA

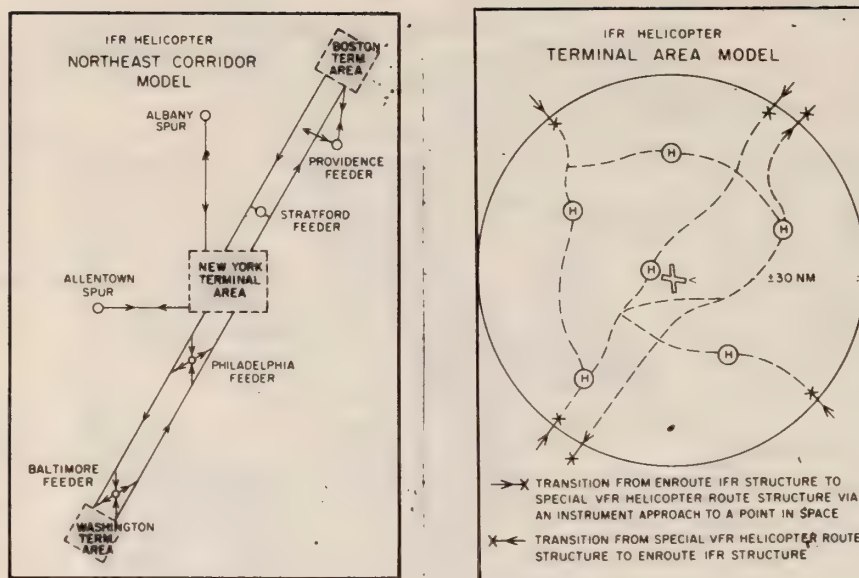
1 Proceed visually from W/P MAP to Downtown Heliport 045°. 3.5 NM or execute missed approach.

1 IFR departure procedure: Climb VFR to 500', direct to W/P MAP. Cross W/P MAP at or above 500'. Climb to 1100' on 219° heading before proceeding as cleared.

Gnd speed-Kts	60	70	80	90	100	110
GS Setting 3.60°	382	446	509	573	637	701

CHANGES: New procedure.

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Concept of Northeast Corridor pilot IFR helicopter project provides discrete, most feasible direct RNAV enroute structure between terminal areas. Terminal area model illustrates concept of transition between IFR enroute structure and special helicopter VFR terminal area route structure.

This project was initiated by Bell Helicopter Company earlier this year under the general auspices of the HAA and in full cooperation with the FAA. Initial flight test work is now being conducted, and some partial use of the corridor is already fully operational by Mack Trucks using a Bell IFR 212 following a discrete helicopter IFR RNAV route structure between Allentown, Pennsylvania, and the New York Wall Street Heliport. ATC delays have been virtually zero, thus demonstrating that even in this high density traffic area the sky is not really crowded, if the right combinations of system concept, air vehicle and dedicated landing/takeoff facilities are employed.

Navigation

Essential to successful IFR, all-weather, operation of helicopters and other VTOL's being developed, is area navigation (RNAV) capability. The current VOR/DME navigation aids provide some degree of RNAV capability, but they are not adequate looking to the expanded use of V/STOL's along the lines visualized previously in this statement. The VOR/DME system has a number of deficiencies among which are line of sight limitations and a low level of accuracy for precision navigation.

To provide precision instrument approach capability today, an ILS is needed for each CTOL runway for which a precision instrument approach is to be made. This obviously is not an economically feasible system for continuation in the future/ ^(nor its proposed MLS successor) if we truly are to have a dynamic air transportation system capable of serving thousands of airports for CTOL's and a virtually infinite number of landing areas for V/STOL's.

Currently, some preliminary thinking (under the general auspices of the OTP) is being given to possible civil aviation applications of the developing DOD Navstar Global Positioning System (GPS). A satellite-based system, validation testing is now underway and expectations are that it will be fully operational by the mid 1980's.

This highly accurate navigation system will have the capability to permit aircraft instrument approaches anywhere a suitable landing area is available. For example, all of the some 12,000 airports in this country could have instrument approach service without the need for installing ILS or other ground-based electronic aids for each runway. An unlimited number of heliports/VTOLports could similarly have instrument approach capability on the surface as well as on elevated structures.

Thus, with a navigation system of this sort, we would have a truly effective tool to realize the tremendous capacity of the airspace

as a transportation medium. This development will, of course, require corresponding traffic handling increased capability in our ATC System.

In Conclusion

I have pointed out that we cannot look with much optimism on getting very many new large jetports in support of our future national air transportation requirements. We cannot, in my opinion, afford as a national air transportation policy to rely on a relatively small number of conventional airports to handle the bulk of our scheduled air service. We need to decentralize and distribute our air services to more locations in the years ahead, serving not only the large metropolitan areas but also many small communities. If we don't do this, I can visualize reaching a virtual zero-growth condition for the nation's airline industry due to its almost exclusive reliance on CTOL aircraft and CTOL airports, even though some of these may be improved somewhat with useful "bandaid" enhancements.

General aviation, on the other hand, may fare better with its greater number of available airports. However, we are now seeing more airport abandonments, particularly in the public-use, privately owned category. Even many publicly owned airports are being threatened with being closed down for real estate development, or are being severely curtailed in their operational capability due to noise restrictions.

I would like to leave the following brief thoughts with this distinguished Subcommittee.

- Let's put more emphasis on the fact that the airspace is truly an unlimited transportation medium and that it is capable of being used for high density, mass transit services, notwithstanding what some of our officials in the Department of Transportation have said.

- Let's get the Federal Government, especially the Department

of Transportation, off its preoccupation with using billions of taxpayers' money to bail out ailing railroads, at the same time failing to support needed funding for our nation's air transportation system.

= Instead, let's think in terms that it would be much more cost beneficial in the public interest to use money being earmarked for artificial maintenance of a passenger railroad "system" to stimulate real mass air transportation capability.

- An important objective of this approach would include financially assisting manufacturers to expedite the production of economically viable V/STOL type vehicles for short haul mass transit air services, particularly for city-center and intraurban commuter applications.

- Another major objective would be to create a dynamic national V/STOLport development program for immediate activation, in cooperation with state and local aviation authorities, together with inaugurating advanced navigation and other advanced technologies for the accomodation of mass air transportation in our Air Traffic Control System.

Finally, I want to express my personal conviction that air transportation and the aviation industry in general can develop to maximum potential only if the FAA is removed from its present subservient, subordinated position in the Department of Transportation and elevated to a position in the federal governmental structure which is commensurate with the great role which air transportation must be able to play effectively in the continued development and security of this great country.

THE COMING SUBSTITUTION OF
TELECOMMUNICATIONS FOR AIR TRAVEL

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GRADUATE SCHOOL OF BUSINESS ADMINISTRATION

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TELECOMMUNICATIONS FOR AIR TRAVEL

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Testimony prepared for the Subcommittee on Aviation,
Committee on Science and Technology, U. S. House of
Representatives.

May 14, 1976

SUMMARY

This paper considers the technological and policy issues associated with the substitution of communications for transportation in intercity travel. It is shown that various forms of communication technology have become available within the last decade that permit substitution, including the development of intercity video conferencing networks and computer-connected conferences. It is concluded that current technology, if suitably exploited, can be made economical for many of the routine transactions that now require air travel.

Experimental evidence, obtained abroad, indicates that many business travelers are willing to make such substitutions if services are available. Evidence has also been obtained that face-to-face contact is not generally required. Analyses are presented of the economic tradeoffs today as well as the energy requirements of air travel compared to communication.

Policy implications involve considering the role of government in encouraging or discouraging substitution, the need for coordinating aviation and communications planning, and the need for determining in quantitative terms the extent of substitution to be anticipated over time.

CONTENTS

	page
SUMMARY.	ii
INTRODUCTION	1
SCENARIO I	2
SCENARIO II	2
SCENARIO III	2
TECHNOLOGY	3
HUMAN FACTORS ASPECTS.	5
SOME EXPERIMENTAL EVIDENCE	6
ECONOMIC CONSIDERATIONS	6
COMPARISON OF TRAVEL AND COMMUNICATION COSTS FROM LOS ANGELES, ...	7
SOCIAL BENEFITS AND COSTS	8
POLICY IMPLICATIONS	9
CONCLUSIONS.	11
BIOGRAPHY	12

INTRODUCTION

Flying for business purposes constitutes a major segment of airline usage and an even larger segment of airline revenue. It is therefore particularly important to consider technological changes that are likely to affect patterns of business travel when evaluating the long-term future of aviation. It is the thesis of this testimony that the next 25 years will see a major change in the way in which business is conducted because of the substitution of communications technology beyond the letter and the telephone for transportation.

This testimony is based on work performed over the last three years at the University of Southern California by an interdisciplinary research team, sponsored in part by the National Science Foundation. Although the bulk of our work focused on the substitution of communications for transportation within a metropolitan area, we also considered the technological and policy issues associated with intercity travel. The discussion that follows represents our conclusions based on our own work and on that of others both in the United States and abroad.

We will begin our discussion by presenting three scenarios that illustrate different types of transportation substitution. The current state of technology is reviewed and the types of additional technological and institutional developments that are required to achieve operational systems are described. It is argued that substituting communications for transportation can have potentially major impact on the aviation business. Prospects are compared to realities and policy issues are outlined.

SCENARIO I

Four executives in New York and three in Boston walk from their offices to a building around the corner that contains the new "CONFERVISION" service being offered for business meetings between major cities. They sit down at a table in front of microphones. Special overhead cameras and "electronic sketchpads" are available for displaying charts, graphs, and text material. Stereo sound is provided so that participants at each end can easily identify who is speaking. Each participant sees all the others. A thirty minute meeting is held and it is agreed that Boston should take additional marketing responsibilities in New England. The meeting is adjourned and the executives head back to their offices...

SCENARIO II

John Smith arrives at his office in the morning and turns on his computer terminal. He types in his identification and asks to see what is new in the "BRAINSTORMING CONFERENCE". Immediately, a set of messages from conferees in his own city and in seven other cities are printed out for him. He looks over the ideas and is struck by one of his own. He types in his idea which then becomes available to all the others involved in this conference. John is in Washington and it is 9:00 A.M. Three hours later, at 9:00 A.M. in Los Angeles, Joe Robinson enters his office and goes through the same steps, picking up all previous messages, including John's...

SCENARIO III

It is the second day of your three-day semi-annual national professional society meeting. You leave your house and go to the Downtown Convention

Center. Yours is one of twenty national meetings going on simultaneously in the Center. The meeting room contains thirty other people almost all of whom work within a fifteen mile radius. You are inter-connected with forty other cities where similar groups meet. On the screen in front of you is a picture of the current speaker larger than life. He is five hundred miles away. When he finishes, questions are directed at him from six different locations. Faces of the questioners are shown on a split screen. The next speaker is from two thousand miles away. The one to follow him happens to be in your room. Since you have heard the local man talk before on this subject, you head out into the "Lobby". The "Lobby" is a separate room in which some forty different pictures are being shown simultaneously. Each of these multiple pictures shows the "Lobby" at the other meeting centers. Looking around, you see your former colleague Joe Snyder who is now on the west coast. You send a message to tell him you would like to talk. You walk over to the video phone booth, are connected, and have an informal talk about what he is doing and what you are doing. The booth is provided with blackboard, chalk, viewgraph projector and other technological aids for communication...

TECHNOLOGY

Each of the foregoing scenarios represents a way of implementing the substitution of telecommunications for transportation. In each case, communications technology is used to provide information and two-way interaction to people that enables them to avoid taking long-distance trips. The first two of these scenarios represent State-of-the-Art technology. Video Conference systems such as are described in Scenario I are available between major cities in both England and Canada. One is being used by the

Metropolitan Regional Council in the New York City area. The computer-connected conference of Scenario II is a reality. A system called FORUM, developed under Advanced Research Projects Agency (ARPA) sponsorship has been in experimental use for several years. Commercial version of such systems (such as CONFER) are now going on-line. I was involved in one FORUM conference where people on the East and West coasts of the United States, in Canada and in England discussed the substitution of communications for transportation. The conference was remarkable in that almost everyone working in this field, worldwide, was able to participate and exchange views. I doubt that the schedules of the individuals involved could have been meshed and funding found to fly them to a common meeting place.

The convention system described in Scenario III is technologically feasible. It is a direct extension of the one-way system currently being used to transmit sporting events (such as heavyweight championships) and product introductions on a nationwide basis.

A number of broad systems studies made since the early 1960's have all indicated that technologically the problem of substituting communications for business transportation requires little innovation, although some developments do require improvement for widespread acceptance. It has been found that for most business situations, telephone bandwidths are sufficient for both voice and data transmissions. The increasing availability of time-shared computer networks and satellite communications systems add to the capabilities of the telephone network that is in place in the U.S.

However, improvements are needed in the software, that is, the computer programs, to allow easier communications between humans (particularly those

not skilled in the use of computers) and the computer networks. Improvements are also needed in the speed and quality of transmission of documents beyond those available with current facsimile techniques, and in the quality of video techniques. PICTUREPHONER, as currently developed by American Telephone and Telegraph Company is not technologically or economically adequate; a more sophisticated video telephone system is required for those few situations where visual as well as auditory contact is required between individuals. Current television technology, requiring wide-band transmission is quite expensive; however, new fiber optic technology is imminent as a replacement. When developed during the next decade, it should drive long-distance television communications costs down to affordable levels.

HUMAN FACTORS ASPECTS

It is often argued that human contact, involving visual cues--pressing of the flesh and body language--is an essential part of a business transaction. Extensive work on this question has been done in Sweden and England. The results of this experimentation indicate that personal contact is needed in initial meetings. Thereafter, business can usually be conducted by use of telecommunications as long as there is periodic (every several months) refreshing of the face-to-face contact. These findings imply that many businessmen who fly for regular meetings will reduce the frequency of their face-to-face contacts. On the other hand, certain kinds of business trips will not be eliminated, such as ones in which an individual has multiple destinations and/or multiple conferences at the same destination. A typical case would be government-contractor personnel who visit a number of funding sources in Washington.

SOME EXPERIMENTAL EVIDENCE

Since many of these actual communications services have become available only recently, and then only in a few major cities, there is little hard data on what would happen if these services were available on a wide-spread basis. Some indication of consumer interest can be obtained from a major study undertaken by Bell Canada and reported by Kollen and Garwood.¹ Responses were obtained from 9600 business travelers along 4 corridors in Canada: (Montreal-Toronto, Montreal-Quebec, Montreal-Ottawa, and Toronto-Ottawa) in early October 1973, immediately before the Arab oil embargo. The study found that approximately 20% of business travelers sampled would not have taken their current trips had an acceptable communications alternative been available. This finding indicates that a significant portion of business travelers are prepared to use some means other than travel to conduct their business. It becomes even more significant portion of business travelers are prepared to use some means other than travel to conduct their business. It becomes even more significant when considering the relatively short distances involved (less than 350 miles) and the relatively cheap energy costs at that time.

ECONOMIC CONSIDERATIONS

In assessing the economic viability of substitution, it must be recognized that the costs of sending an executive on a trip, particularly

¹Kollen, J. H. and John Garwood, Travel/Communication Tradeoffs: The Potential for Substitution Among Business Travellers. The Business Planning Group, Bell Canada, Montreal, Canada, (April 1975).

from coast-to-coast, are quite high. The following is a comparison of communications and transportation costs for executive meetings as of January 1, 1976 developed by my colleague, Jack M. Nilles²:

COMPARISON OF TRAVEL AND COMMUNICATION COSTS FROM LOS ANGELES

Terminus	Duration of Conference	Costs ^a		
		Travel ^b	Telecommunications ^c	
			Common Carrier	Common Carrier Specialized
New York	1 day	473.23	225.21	189.09
	2 days	498.23	450.42	378.18
	3 days	523.23	675.23	567.26
Chicago	1 day	370.53	214.94	178.82
	2 days	395.53	429.88	357.63
	3 days	420.53	644.82	536.45
San Francisco	2 hours	72.50	53.70	Service
	4 hours	72.50	117.19	not
	8 hours	72.50	234.38	Available
	2 days	97.50	449.16	

^aCosts are estimated for January 1, 1976, and include all applicable taxes.

^bAir travel cost includes the following; coach round trip air fare, cost of flight time plus 1.5 hours travel to and from terminal, at \$11.00 per hour, and lodging (for New York and Chicago only) at \$25.00 per night, with the number of nights equal to the number of days.

^cTelecommunications costs include an effective lease rate of \$2.45 per hour for a CRT terminal with conference (speaker) phone and a facsimile machine (all time-sharing the line). The common carrier is assumed to be the Bell Telephone System. Daytime, station-to-station rates were assumed. The specialized common carrier is assumed to be MCI Telecommunications, using its EXECUNET service, which is available from any push-button telephone in the cities served.

²Jack M. Nilles, Frederick R. Carlson, Paul Gray, and Gerhard J. Hanneman, The Telecommunications-Transportation Tradeoff: Options for Tomorrow, John Wiley and Sons, New York (1976).

Even at present costs, telecommunications are economically competitive.

It is reasonable to expect that in future years:

- air fares will rise as energy costs rise
- salary costs for executives will rise
- telecommunications technology will improve and costs will decrease compared to energy and salaries.

All of these arguments imply that communications substitution for transportation is viable economically not only at this time, but will continue to be so over the long term.

SOCIAL BENEFITS AND COSTS

Substitution of communications for air transportation is intuitively appealing: rather than sending 180-pound people from place to place to talk to one another, send electronic signals that weigh nothing. There are exciting social benefits that result:

- considerable savings in energy
- reduced requirements for capital investment
- reduced pollution levels
- reduced noise levels

to mention just a few. However, there are also social costs to be anticipated. Many industries, including hotels and restaurants, depend significantly on the business traveler. These industries are labor intensive; thus, there may be net decrease in employment. The economics of commercial aviation are geared to the business traveler, who pays the highest rate. Removing some of the business travelers would reduce load factors which, in turn, would drive fares up, which increases substitution, which raises fares some more, in an ever-increasing spiral. Increased costs would

affect the mobility of Americans and could have major impacts on tourism. It is not possible at this time to state whether the social benefits would exceed the social costs.

Another important consideration is that the substitution of communications for air transportation would, in the long run, change the nature of metropolitan areas. At present, most major businesses are located in cities served by metropolitan airports. The availability of an air hub is a factor in site selection, particularly for corporate headquarters. If air transportation becomes less of a factor, corporations would have few incentives to stay close to large cities, possibly speeding the decay of megalopoli while increasing the number and dispersion of small to medium sized cities. Such changes could also affect the mix of short- and long-haul air traffic.

POLICY IMPLICATIONS

Based on what we know at present, the following are important policy considerations:

1. The decision to substitute communications for air travel will, most likely, be made by individuals and by individual corporations. Government can encourage or discourage such substitution to a certain extent because it regulates both aviation and communications. Priorities such as energy, environment, and safety may lead in the direction of encouraging substitution. Regulatory measures available include rate setting, standard setting, route awards, and subsidies.

2. Communications and transportation planning must be integrated. Specifically, long-range planning for aviation must be coordinated with long range communications planning if a meaningful national aviation policy is to develop. At present there appears to be no such coordination among the CAB, the FAA, and the Office of Telecommunications Policy.
3. The magnitude of the impact on future aviation demand cannot be predicted with any confidence at this time since it depends on actions in both the private and public sectors, the pace of technology, and the costs of energy, communications, and air travel relative to one another. The question is of sufficient importance that a major study of the impact should be undertaken which takes these factors into account and quantifies them. Techniques of Futures Research, including Delphi and Cross Impact, are applicable and should be used in such study. A proper role of Congress would be to urge its Office of Technology Assessment or a branch of the Executive to sponsor the study and to provide the necessary funding.

CONCLUSIONS

The National Travel Survey issued by the U.S. Travel Data Center indicates that roughly half of all commercial flying is for business purposes (4th quarter report, 1975). The developments discussed in this testimony indicate that the boundary between communicating and traveling for business purposes is shifting significantly in the direction of communications. It can be considered quite likely that for both short-haul and long-haul trips, communications will be substituted for air travel by a significant fraction of present-day travelers. Such substitution will reduce the anticipated demand for air travel, all other things remaining equal. Therefore, in the deliberations of this subcommittee, this likely technological development must be taken into account in assessing the future of aviation.

BIOGRAPHY

Paul Gray is Chairman of the Department of Quantitative Business Analysis at the University of Southern California. He is also a Senior Research Associate in the Center for Futures Research at the University.

Prior to joining the University of Southern California, Dr. Gray was Professor at the Georgia Institute of Technology and Stanford University. From 1962 to 1970 he was a Senior Research Engineer and Director of the Institute-Wide Program in Transportation at Stanford Research Institute. He has also been employed by General Dynamics-Fort Worth and Solar Aircraft Company. He holds a B.A. in Mathematics and Physics from New York University, and M.A. in Mathematics from The University of Michigan, an M.S. in Electrical Engineering from Purdue University, and a Ph.D. in Operations Research from Stanford University.

Dr. Gray's research has centered on a variety of problems in transportation, including air traffic control, air defense, automobile safety, airport location, public safety in transportation, the long-range future of transportation, and, most recently, the trade-offs between communication and transportation.

He is currently Secretary of The Institute of Management Science.

Mr. J. C. Green, Manager
of Operations Analysis,
Sikorsky Aircraft

SIKORSKY AIRCRAFT RESPONSE TO
HELICOPTER ASSOCIATION OF AMERICA

"FUTURE OF AVIATION"

I. National Transportation Context

The aerospace industry has played, and will continue to play, a vital role in the development and growth of the United States. The vastness of the United States, associated with its heavy emphasis on personal freedom and decentralized control, calls for a rapid system of communications within its own borders. Furthermore, the role that the United States plays as a world leader spans this need for the communications system to all parts of the globe. The airlines of the United States have built up, since the 1930s, a global transportation network unparalleled by any other country. In support of the airlines, the U. S. aerospace manufacturers have provided products that are second to none in their role of economic transportation vehicles.

A measure of the unique significance of the aviation industry is the fact that it accounts for 19% of the total transportation employment of the United States.

From the point of view of our own industry, that is, helicopter production and operation, we are, we believe, at a different point on an industrial growth cycle than our fixed-wing colleagues. We are now at a point in time when the period of rapid development in the fixed-wing sector is drawing to a close. There are, of course, many exciting areas left to explore, such as the application of the supersonic flight to commercial aviation, but, in the main, future growth in the fixed-wing sector will be mainly dominated by the growth in the U. S. and to some extent the world's economy.

On the other hand, the helicopter industry is at a point in time comparable with the introduction of the commercial jets in the 1950s. We expect that very large strides will be made in the next two decades, whereby the helicopter becomes a much larger element in the life of the U. S. citizen. We believe this because we are on the threshold of major improvements in the operating economics of the helicopter. Such improvements in economy have always provided key turning points in the growth of transportation systems. In these circumstances, the role of the U. S. Government in relation to R&D can be vital in assisting the helicopter industry successfully translate from adolescence to maturity.

II. Economic Issues Related to R&D

The U. S. aerospace industry, including helicopter manufacturing, has consistently provided a positive contribution to the nation's balance of trade even in the early 1970s when three of the four years from 1971 through 1974 showed negative balances. The latest imbalance for the U. S. in calendar 1974 was a negative \$2,984 million. The aerospace industry contribution that year was a positive \$6,350 million. The 1975 contribution was \$7,074 million, a growth of 11.4%.

Helicopter exports have grown at the rate of 35.7% per year compounded from 1970 through 1975, while aerospace exports grew at the lower annual rate of 18.1%. Back in 1970, helicopters also accounted for only 1.5% of the total efforts of U. S. aerospace products, but by 1975 that figure had nearly doubled to 2.9%. Rotary wing sales, therefore, have made a strong and consistent contribution to the nation's balance of trade.

With the Government anxious to avoid trade deficits in the future, the aerospace, aviation, and helicopter industries must remain competitive and provide attractive products for world markets. To sustain a high level of exports will require support through the development of new products or processes. The success achieved by the U. S. aerospace industry in meeting its goal will be impacted by the attitude taken by the U. S. Government on R&D.

III. Institutional Questions Related to R&D

We believe that the Government should actively encourage and support NASA to take a positive research role to the support of the whole of the U. S. helicopter industry. The areas of research that it undertakes should be agreed on an industry-wide basis.

IV. Future Needs and Opportunities

As described in Section I, we foresee a continuing vital role to be played by the aviation industry. We see no developments on the horizon that will impact upon this view for the remainder of this century. While improvements in other forms of communication, such as the telephone, will continue to be made throughout the period, the role of direct contact will continue to be the dominant mechanism used for business and personal dealings. There is even reason to believe, with the obvious decay in writing skills, plus the associated degradation in means of transmitting written communications, that the requirement for human contact in the future may increase noticeably above today's levels. The automobile and the aircraft are demonstrably the most efficient forms of personnel transport that permit these contacts to be made.

We see the greatest growth in the aviation sector will be in expanding the role of the helicopter in its daily commercial use. While its role in specialist transportation functions is well appreciated at this time, we predict a much greater involvement in urban and executive transportation. Ease of construction of heliports and, hence, ease of access and minimization of land use will be important factors in the commercial growth of helicopter usage.

Specifically, the large growth of the number of helicopters in civil service and the continuing development of helicopter applications in the industrial fields will require expanded R&D in noise and pollution reduction and energy conservation through development of engines with lower fuel consumption and helicopters with lower power requirement for hover and forward flight. Effective helicopter utilization will require development of

sophisticated low cost navigation and air traffic control system to permit high density operation of helicopters in severe weather, day or night, independently of fixed-wing operations. More emphasis will have to be placed on hardware demonstration of new concepts prior to commitment to production.

For example, the Sikorsky ABC helicopter has now demonstrated its superior performance in flight to 160 knots and is capable of reaching speeds of 300 knots with auxiliary propulsion. The ABC demonstrator is the only existing flight vehicle which can hover efficiently and fly at speeds to 300 knots. The potential application to the civil, Air Force, and Navy markets is great. This helicopter should be developed.

We should also:

- a. Evaluate solid state cockpit displays to reduce pilot work load by providing information by command and exception. The emergence of light emitting diodes, microprocessors, optic fibers, and lasers should make possible simplification of the pilot's instrument display by showing information as required. There is a need to integrate the technology in a system for commercial and military application.
- b. Improve aerodynamic performance in hover and low speeds and cruise flight performance with emphasis on vertical drag evaluation in hover and vertical climb, parasite drag in forward flight, dynamic pressure at the tail rotor and empennage, maneuver performance, and rotor system dynamic loads. Develop improved body geometry, airfoils, and rotor geometry.
- c. Improve helicopter gust response with emphasis on use of fly-by-wire and fiber optics technology.
- d. Develop internal and external noise reduction technology to reduce noise without degrading the performance and fuel economy of new helicopters if new Federal statutes are to be met. Specifically, research in rotor geometry to reduce main rotor and tail rotor noise is required so that helicopter performance and costs are not unduly compromised in meeting proposed noise requirements.
- e. Investigate means of continuing to reduce helicopter vibration by both vibration analyses and improved vibration control concepts.
- f. Develop structures concepts to reduce airframe weight and costs using advance materials. Develop structures with good energy absorption to improve crashworthiness. Obtain environmental characteristics of composite structures and provide data for use by designers.

The facilities needed to assist in bringing these developments about include:

1. More demonstrator aircraft programs to demonstrate and exploit new technology and to establish criteria, e.g., civil helicopter demonstrators.

2. The Rotor Systems Research Aircraft (RSRA).
3. Improvement of the NASA 40 x 80-foot wind tunnel.
4. Facilities for automation of composite airframe manufacturing.

V. Policy Questions Related to Technology Transfer

The U. S. helicopter industry has supported the development of foreign helicopter manufacturers with licensing of overseas production of U. S. designs. While this attitude has played a key role in the evolution of a worldwide helicopter industry, the foreign helicopter manufacturers have now reached a point where they are capable of competing on largely equal terms. It is likely that future licensing agreements will involve close scrutiny of the long-term impact on U. S. export business.

VI. Government Role in Helicopter R&D

The current roles and missions assigned to the military services and the rule that R&D be related to currently stated requirements leaves many voids in R&D, both in near-term requirements as well as in potential capabilities.

For example, while the Air Force has requirements for long-range, high-speed helicopters for search and rescue missions, USAF depends on other services to perform helicopter R&D. The U. S. Navy performs little basic helicopter research and exploratory development. Navy RDT&E concentrates on Engineering Development of new helicopters and improvements to helicopters in the fleet.

The U. S. Army engages in Exploratory and Advanced Development of helicopters but is constrained to R&D related to specific current requirements such as UTTAS and the Advanced Scout Helicopter (ASH) with heavy emphasis on military operational requirements. The Army has no current requirement for high speed. The U. S. Coast Guard has requirements for better search and rescue helicopters but does not perform exploratory or advanced helicopter development.

The growing civil helicopter market requires improved helicopters for the many applications in industrial and transport fields and to meet growing national needs. A central source of new technology is needed to help the helicopter industry meet these needs with helicopters that can meet foreign competition. The industry may have difficulty in acquiring the required technology in a competitive cost environment. NASA should supply technology to the helicopter industry as it does for the remainder of the aerospace industry. NASA is best equipped to do the forward looking helicopter technology acquisition as it has done so well in other fields. NASA should also acquire the technology that will permit the industry to meet emerging environmental requirements and civil helicopter regulations. The FAA should develop the navigation and air traffic control facilities required to provide high density, all-weather flight in a system independent of fixed-wing traffic. The National Air Transportation Policy should address these issues in a way to promote a healthy and competitive helicopter industry.

Much of the R&D performed by DOD agencies and, in particular, the R&D accomplished by the U. S. Army Air Mobility Laboratories has general application to helicopter development, both military and civil. However, NASA effort is additionally required to perform more basic scientific research and to address the problems peculiar to civil air transportation. Specifically, NASA should develop and flight demonstrate the technology required to provide high-speed (300 knots) passenger transports of 60- to 100-passenger capacity which can meet environmental and regulatory requirements. National policy should provide for coordinated effort by the military and civil agencies to assure that no gaps exist and that maximum advantage is taken of R&D pursued by all agencies of the government.

VII. Status of Foreign Competition

While the competition from foreign helicopter producers is already high, the U. S. helicopter industry is now facing a potential new problem from European manufacturers with the merging of their requirements and the planning of common production programs.

The four major European helicopter manufacturers - Aerospatiale of France, Westland in the U. K., MBB in Germany, and Agusta in Italy - signed a Memorandum of Understanding last summer indicating that they had reached agreement on basic principles of collaboration for future joint programs. The agreement covers design of new aircraft, development or modification of existing designs, and exchanges of technology. No specific aircraft programs were involved. There are difficulties involved with this approach. The diversity of political and economic requirements among the nations of Europe and the need to standardize on a few specific aircraft programs that would generate large enough production runs to produce economics of scale are major obstacles that must be overcome.

European industry is largely government supported, however, either directly or through subsidies in the areas of research, design, development, sales and marketing. Strong government support in these areas over time could erode traditional U. S. markets abroad, especially in the absence of a strong U. S. technology base and the introduction of competitive new products at competitive prices. The advantages implicit in the broad-based U. S. market can be offset very quickly by a variety of low-cost aircraft with competitive performance features, produced under foreign government subsidy. Development of better products across the entire spectrum of the industry (including engines, airframes, avionics, manufacturing methods, etc.) is of paramount importance, therefore.

VIII. DOD View

At this point in time, virtually all commercial helicopters are direct derivatives of government-funded military programs. While this aspect cannot be expected to disappear rapidly, an indication of the translation of the industry into a mature phase is the willingness to develop products specifically for the commercial market. The Bell 222 and Sikorsky S-76 are products of this new thinking.

CESSNA AIRCRAFT COMPANY
WICHITA, KANSAS 67201

MALCOLM HARNED
PRESIDENT

May 14, 1976

The Honorable Dale Milford, Chairman
Subcommittee on Aviation and Transportation R & D
Committee on Science and Technology
U. S. House of Representatives
Suite 2321, Rayburn House Office Building
Washington, D. C. 20515

Dear Mr. Milford:

We appreciate the opportunity to contribute to the hearings of your committee on the "Future of Aviation." In the enclosed paper we have summarized our views on the future prospects, problems and opportunities for General Aviation. We feel that this important segment of the aviation community, in which Cessna Aircraft Company plays an important part, will continue to develop and increase its vital role in the economic and social structure in our country and around the world.

Development of an improved technology base will assist in the growth and improvement in usefulness of General Aviation. The Federal Government, through NASA, can certainly play a significant role in assisting in the development of new basic technology. It is very important that as technological capabilities are being advanced the Federal Government should assist in providing economic, regulatory and an international trade environment that will allow the best utilization of the resources of General Aviation for maximum public benefit throughout the world.

It is hoped that the information submitted herewith will be useful in the deliberations of your committee. We shall look forward to learning the results of the hearings on the "Future of Aviation."

Very truly yours,


Malcolm Harned

Enclosure

FUTURE OF GENERAL AVIATION AND CIVIL AVIATION R&D POLICY

Prepared by Malcolm Harned, President
Cessna Aircraft Company

SUMMARY

During the past three decades General Aviation has experienced substantial and sustained growth. This has been due to major increases in the need for and the efficiency of this form of transportation. Similar growth and further improvement in usefulness is predicted for the remainder of this century.

Realization of the expected growth and increased benefits from General Aviation is highly dependent on the environment provided by Federal Government. Economic, energy, regulatory, tax and trade policies will have major impact on the ability of all segments of the General Aviation community to utilize their extensive resources to enlarge and improve the contribution of General Aviation in the United States and for our foreign customers.

The Federal Government aviation R&D policy will also have an impact on the development of General Aviation. In the past, NACA contributed much to the technical development of aviation, and today NASA has the capabilities to make a significant technical contribution. That contribution should be in research and basic technology development -- not in applications engineering or prototype development. These activities require the synthesis and weighing of many considerations -- technical, operational, manufacturing, marketing and economics. The General Aviation manufacturers have the background and perspective in these complex fields, and can do the applications engineering and product development job far more efficiently and effectively than a government agency, such as NASA.

Areas in which NASA research could be of value in the continuing development of General Aviation are external noise, piston engine exhaust emissions, improved airfoils, composite structure, structural adhesives, structural loads determination, crash impact dynamics, and stall-spin research.

An additional area of particular importance for government support is that of research and development within the aircraft industry itself where we strongly recommend some form of tax incentive to stimulate private investment in this area. This is particularly important because competitive foreign aircraft companies have their R&D almost entirely subsidized by their governments. In addition, to make NASA's basic technology research of value in maintaining our world leadership in aviation it is essential that some security system be created to restrict this technology to United States manufacturers for some reasonable period of time.

FUTURE OF GENERAL AVIATION AND CIVIL AVIATION R&D POLICY

Prepared by Malcolm Harned, President
Cessna Aircraft Company

THE ROLE OF GENERAL AVIATION

The use of General Aviation has more than doubled each ten years for the past three decades. Similar or greater growth is expected throughout this century as both capabilities and needs continue to increase. Of particular importance in pushing this growth is the increasingly vital and efficient role of General Aviation in providing the only air service to the 96% of this nation's airports not served by airlines. In most cases these represent small and medium-size communities which depend on General Aviation to a significant degree for their commerce, communication and emergency health services.

General Aviation is and will continue to be a powerful force in countering the trend toward further urbanization, with its many problems which degrade the quality of life of United States citizens. In many of the lesser developed areas around the world General Aviation provides the vital link to make possible efficient development of natural resources needed to support and improve the indigenous economy ahead of the development of highways and railroads. The current high cost of fuel and the anticipated increases in the future appear to assure that economic transportation by large, high speed commercial transports will only be economically practical between large cities. Consequently, the air transportation among medium and small cities will become increasingly dependent on General Aviation aircraft. This will be particularly true of the essential business travel. It is of importance to recognize that the majority of General Aviation aircraft are very energy efficient and our continuing development is planned to make them even more so.

FACTORS INFLUENCING THE DEVELOPMENT OF GENERAL AVIATION

Many factors can contribute to an orderly and effective growth pattern for General Aviation -- including the national civil aviation R & D program. However, we would like to emphasize the extreme importance of the Federal Government providing an atmosphere conducive to efficient growth of General Aviation to the benefit of citizens of the United States and other countries. Non-tariff restraints to trade -- including those imposed by our own government -- seriously hamper the export of our products. The proliferation of unnecessary, unproductive and costly regulatory activities from many segments of the federal bureaucracy increase the cost of needed aviation services. Also affecting the ability of the General Aviation industry to provide the benefits of which it is capable is the basic economic environment, greatly affected by the Federal Government through fiscal, taxation and energy policies. Our government needs to work to minimize aircraft importation barriers imposed by foreign governments. We strongly urge the Congress to consider these factors carefully as they are far more vital to the "Future of Aviation" than government-sponsored R&D.

FUTURE OF GENERAL AVIATION AND CIVIL AVIATION R&D POLICYFACTORS INFLUENCING THE DEVELOPMENT OF GENERAL AVIATION (Cont'd)

In the technical area, the factors we see as most important to the growth and improvement in capability of General Aviation are overall economics, fuel efficiency, safety, operations in weather, navigation, communication and ATC systems, and passenger comfort.

FEDERAL GOVERNMENT RESEARCH AND DEVELOPMENT

We believe that the Federal Government, through NASA, can make a worthwhile contribution to the development of General Aviation. Following are some of our thoughts on what NASA's role in support of General Aviation should be.

Maximum emphasis should be placed on development of basic technology. This is the field in which NASA has unique capabilities. There is far too much focus of interest and activity within NASA on engineering applications and systems, as contrasted with research and technology development. The contribution that NASA is making in the field of aeronautics suffers considerably as a result of this diversion of effort away from research.

NASA should concentrate on developing the highest level of in-house technical capability in the field of aeronautics research, and concentrate its activities on in-house research and technology development. The trend for NASA to become a contracting agency and "money manager," rather than an organization for research and technology development, really degrades the value of the agency in terms of making the contribution that it is uniquely capable of making.

We are strongly opposed to recent proposals for NASA to design and develop prototype aircraft for commercial application. We think the misuse of capabilities that would result, both in NASA and in industry, is obvious, and must be avoided.

We are concerned that the current aviation programs in NASA tend to be identified solely on the basis of short-term specific project application. Some of NASA's research effort should be devoted to the pursuit of promising long-range aerodynamic, structural and propulsion concepts, independent of a fully-identified application. Historically, some of the best technical advances have come where the technology has been the driving force.

Specific areas in which we would like to see NASA continue or initiate research in support of General Aviation are as follows:

1. External Noise.

Research is needed on the operational and design factors affecting external noise, and refinement of the means of measurement and analysis of noise data. This is particularly important in view of

FUTURE OF GENERAL AVIATION AND CIVIL AVIATION R&D POLICYFEDERAL GOVERNMENT RESEARCH AND DEVELOPMENT (Cont'd)

the recently imposed regulatory requirements enacted by the FAA and by various foreign countries, and by impending ICAO noise standards.

2. Piston Engine Exhaust Emissions.

NASA can play an important role in providing basic technology in this field. Regulations have been established by the EPA which limit emissions of piston-engine aircraft produced after December 31, 1979. The technology is not available to meet these regulations. A concerted effort is required to establish the levels of emissions that are feasible, and to restructure the EPA regulations to obtain maximum emissions reduction without unacceptable penalties in the cost, safety or utility of General Aviation aircraft.

3. Improved Airfoils.

The research program that NASA has underway on airfoils for both low-speed and high-speed application should be continued and amplified. These improved airfoils are applicable to both wings and propellers. Benefits in improved economy and operational capabilities should be made possible by this research.

4. Composite Structures.

High-strength, high-modulus composite materials, such as boron and carbon fibers, are today extremely costly for application in General Aviation. Although their cost is continuing to come down as development and application continues, their use for the foreseeable future will probably be restricted to those areas where they provide large benefits. One such area is in propeller construction, where composite structures show promise of reducing weight by up to 50%. An aggressive research program on composite propellers appears highly appropriate.

5. Structural Adhesives.

Research on the basic materials, processes, strength and durability characteristics of adhesive bonding materials could provide significant long-range benefits in improved strength and reduced cost of bonded structures.

6. Structural Loads.

A program has been underway for several years at NASA to measure the loads imposed on a variety of aircraft during operations throughout the United States. This program continues to provide needed information on the gust and maneuvering-load environment to which aircraft are exposed.

FUTURE OF GENERAL AVIATION AND CIVIL AVIATION R&D POLICYFEDERAL GOVERNMENT RESEARCH AND DEVELOPMENT (Cont'd)7. Crash Impact Dynamics

The program underway at NASA-Langley involving controlled crashes of full-scale General Aviation aircraft is providing basic data on crash impact dynamics. This research should provide, in the long run, data useful in the design of future aircraft, and should be continued.

8. Stall-Spin Research

The program underway at NASA to obtain a better understanding of the stall-spin characteristics of light aircraft should be continued. This involves many complex phenomenon not clearly understood, and progress to date has been slow. However, there does exist the long-range potential of improving the understanding of stall-spin phenomenon, and improving the safety of future aircraft.

9. Avionics.

Considerable effort has been spent by NASA on avionics for General Aviation. To date, little of value has come from this program. Much of it has been conducted a full generation behind in technology, relative to systems which were then operational in a large number of airplanes and which were delivered at costs substantially below that which could have been achieved by the NASA approach. This is not to say that NASA research in avionics can never be of benefit to General Aviation, but it appears clear to us that NASA avionics research efforts should be focused on basic technology, rather than systems design and development. The highly competitive avionics industry is fully exploiting the available technology of all fields -- space, missiles, military aircraft, computers and consumer products -- in a "real world" operational and economic environment.

INDUSTRY RESEARCH AND DEVELOPMENT

However, we believe one of the most important areas for your consideration is the promotion of industry research and development. The foreign competition we face is that of foreign governments supporting directly the aircraft development at either private or nationalized companies, not in governmental research agencies. The only way we will produce advanced aircraft is through R&D programs in our aircraft companies where the specific designs and manufacturing processes must be developed. It should be possible for the government to stimulate and accelerate such industry R & D by some form of tax incentive. A possible example of such a tax incentive would be to allow the deduction of an amount equal to the company's annual R & D expenditure from pre-tax profit for capital investment. This would have the added advantage of providing additional capital for investment in productivity-improving equipment.

FUTURE OF GENERAL AVIATION AND CIVIL AVIATION R&D POLICYINDUSTRY RESEARCH AND DEVELOPMENT (Cont'd)

It must also be recognized that one of the principal reasons NASA offers for increased budgets is to provide technology to maintain the United States leadership in aircraft production. This is a fallacy until such time as an effective security system is established which preserves this technology for U. S. industry. At the present time our foreign competitors are using whatever technology NASA develops plus their government's financing of their own R & D to advance their competitive position.

Consequently, it is our conclusion that if it is your committee's objective to maintain U. S. leadership in aviation the following four basic approaches be undertaken:

1. Our Government should strive to create a favorable regulatory and taxation environment, both at home and abroad.
2. NASA should conduct research to develop basic technology for use by the U. S. industry.
3. A NASA security system should be established to give U. S. firms the advantages of the results of costly NASA research programs well in advance of their availability to foreign industry.
4. An effective form of tax incentives should be developed to stimulate more R & D effort in the private aircraft industry to make it more competitive with foreign government subsidized industry.

* * * * *

Your committee should recall that the United States leadership in the automobile industry completely dominated the world only a few years ago. In approximately one decade our world position changed dramatically. We could easily experience the same result in aviation with the government subsidized aircraft design and development in foreign companies (using all of NASA-developed technology at no cost) making it difficult for United States manufacturers to compete.

BIOGRAPHICAL INFORMATION

Malcolm Harned is president and a member of the board of directors of Cessna Aircraft Company. Before he became president he served in the executive capacities of group vice president, senior vice president-aviation operations, and executive vice president. Prior to joining Cessna in 1970 he was executive vice president/general manager - aircraft division of Gates Learjet Corporation. Until 1967 he served in various executive capacities of increasing responsibility at the Hughes Tool Company, Aircraft Division. He joined Hughes as vice president - engineering and at the time he left he was senior vice president. Prior to that he spent five years as program manager for the nuclear turbojet engine program at General Electric. Mr. Harned's career in the aircraft industry also includes several years in engineering management at Marquardt Aircraft Company and North American Aviation, Inc. Mr. Harned has a B.S. degree in mechanical engineering from the University of Kansas and a M.S. degree in aeronautical engineering from California Institute of Technology.

Cessna Aircraft Company is the world's leading manufacturer of General Aviation aircraft -- producing each year the majority of all the aircraft built throughout the world. The model line is very complete with over two dozen separate models being produced including everything from a two-place trainer through the Citation business jet. As well as the leading passenger-carrying aircraft also included in the product line are utility aircraft, bush aircraft, float planes, and ambulance aircraft. Cessna is also the leading producer of agricultural aircraft. In the military field Cessna supplies the Air Force primary trainer (the T-41), the basic jet trainer (the T-37) plus the A-37 attack aircraft. Overall, Cessna has produced nearly 130,000 aircraft, by far the largest number produced by any company.

LOCKHEED AIRCRAFT CORPORATION

BURBANK, CALIFORNIA 91520

WILLIS M. HAWKINS
SENIOR ADVISOR

May 3, 1976

Honorable Dale Milford
Committee on Science and Technology
U. S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, D. C. 20515

Dear Congressman Milford:

As requested in your letter of April 9, I have a few suggestions that I hope will be helpful to your Subcommittee on Aviation and Transportation R&D. I recognize that your committee responsibilities include other modes of transportation and that you must balance your recommendations to Congress among air, land, and water systems. Thus my first suggestion is that the government, in developing transportation policies, seek some means of focusing its investments in the areas where maximum service is being rendered rather than on the basis of historic patterns of expenditure. Figure 1, attached, is an illustration of the contribution in passenger miles of service by various passenger systems. Such a total system contribution might be used to determine the distribution of government R&D expenditures.

The essential problem that faces the aircraft industry today is that the continuing depressed state of the transportation business, reflecting both the economy and the awkward history of rate setting and route allocation imposed on the airlines, has inhibited the demand for new transports in spite of the fact that the technical state of the art exists for:

- o Quieter transports
- o More emission free engines
- o Higher performance STOL aircraft
- o Economically useful VTOL transports
- o Cargo transports that are competitive on cost/ton mile with surface transports for many commodities
- o Wide body aircraft with nearly 25% improvement in fuel efficiency over present wide body transports
- o Substantially safer private owner aircraft
- o Accelerating the R&D directed at the use of different fuels with little or no emission problems and substantial performance advantages

All of these improvements promise substantial benefit to society if some means can be found to sponsor their introduction into use. The problem of accelerating the utilization of technology will not be solved by demonstration in prototypes. The solution is to find some way for incorporating this technology into saleable articles and to make it possible for operators to purchase such equipment. Almost no capital is available today for investment in new products.

In addition to the lack of capital, other inhibitions exist which are of a more complex nature. These include the lack of ground facilities and community welcome necessary to bring new aircraft closer to the passengers which they could serve. This is the problem faced by STOL and VTOL systems.

A similar problem exists in the use of new fuels, particularly hydrogen, which would answer many atmospheric emission problems and provide a substantial step function in aircraft performance.

In the face of the need for capital and the need for a ground environment to be compatible with advanced air transportation services, it may be useful to consider sponsorship of complete demonstration systems. Candidates for such demonstrations could be:

1. A total "in city" VTOL system including new aircraft and enough rooftop VTOL ports and landing aids to comprise a complete system. The capital cost is believed to be substantially lower than a BART or the Washington subway system and, unlike these systems, a small start with subsequent expansion is simple.
2. A complete airline system utilizing an advanced hydrogen powered transport including facilities for delivering the fuel and servicing the aircraft. This could be either a passenger or a cargo system, but should be designed to serve a major going market segment as a pioneer route. It might be a sound idea to combine a hydrogen cargo system demonstration with a military transport system. A Frankfurt to New York to Los Angeles cargo airline might prove to be useful to many.

The essential element of these suggestions is that no single prototype aircraft demonstration solves enough of the manufacturers' (or the airlines') problems to attract new capital. Community resistance, the need for extensive ground facilities, certification of the aircraft and ground facilities, and the

start-up costs for tooling all demand capital to convert a sound idea into effective use.

Having the government participate as a sponsor for an entire program raises the spectre of the waste that attended the SST program and thus some of the lessons learned in that episode may be in order. My version of these lessons includes:

a. The competition was far too long and too detailed, resulting in the expenditure of major manpower and technical development effort that would have been wasted by the losers even if the program had continued. Major subcontracting families were developed, half of which lost their investment, and the data thus developed was not essential and was scarcely reviewed in the final selection. The solution may be to use a combination of airline operators as evaluators (as partially done in the SST) but to rely on their judgment for the selection rather than massive cost analyses and detail design. Another element of the solution may be to arrange the request for proposal so that the "losers" participate as subcontractors to the winner thus contributing their talent in support of the program.

b. By contracting for certified articles and the supporting ground facilities, the operating airlines could be sure of having an operational entity rather than being faced with developing an operational article from a poorly defined prototype.

c. By certifying and supporting a whole system, the government thereby assists an operator in its negotiations with the community and can support, with funds, any change in system concept required by valid community concerns. The government becomes a helpful sponsor rather than an intermittent adversary or a politically biased judge.

In summary, I am suggesting that the government probably will have to assume a sponsor role to utilize the technology which is now available - and I am further suggesting that such technology will benefit the public in a substantial way. I am also suggesting that such sponsorship will have to be extensive enough to carry the experiment into model operation, serving customers, before such a demonstration is convincing to the capital market.

Bringing the benefits of new technology to the private pilot may be even more difficult, even though less expensive. My convictions include:

Honorable Dale Milford

-4-

May 3, 1976

1. The FAA is overwhelmingly aimed at airline support and the facilities for the private pilot are over designed and over supported to the detriment of the potential customer who can ill afford the equipment to get into the system.
2. New technology can be incorporated with less risk in the private airplane field because test failures are less expensive. Sponsorship, by the government, of certification of new materials, new configurations and advanced power plants would help and would be relatively inexpensive.
3. With respect to new power plants, it would be helpful to the private owner if some versions of automotive power plants (also now being aided by the government) could be certificated to aircraft use with automobile fuel, new ignition and injection concepts, etc., in order to reduce costs of aircraft propulsion, help solve emission problems, and assist in making spare parts and maintenance inexpensive.

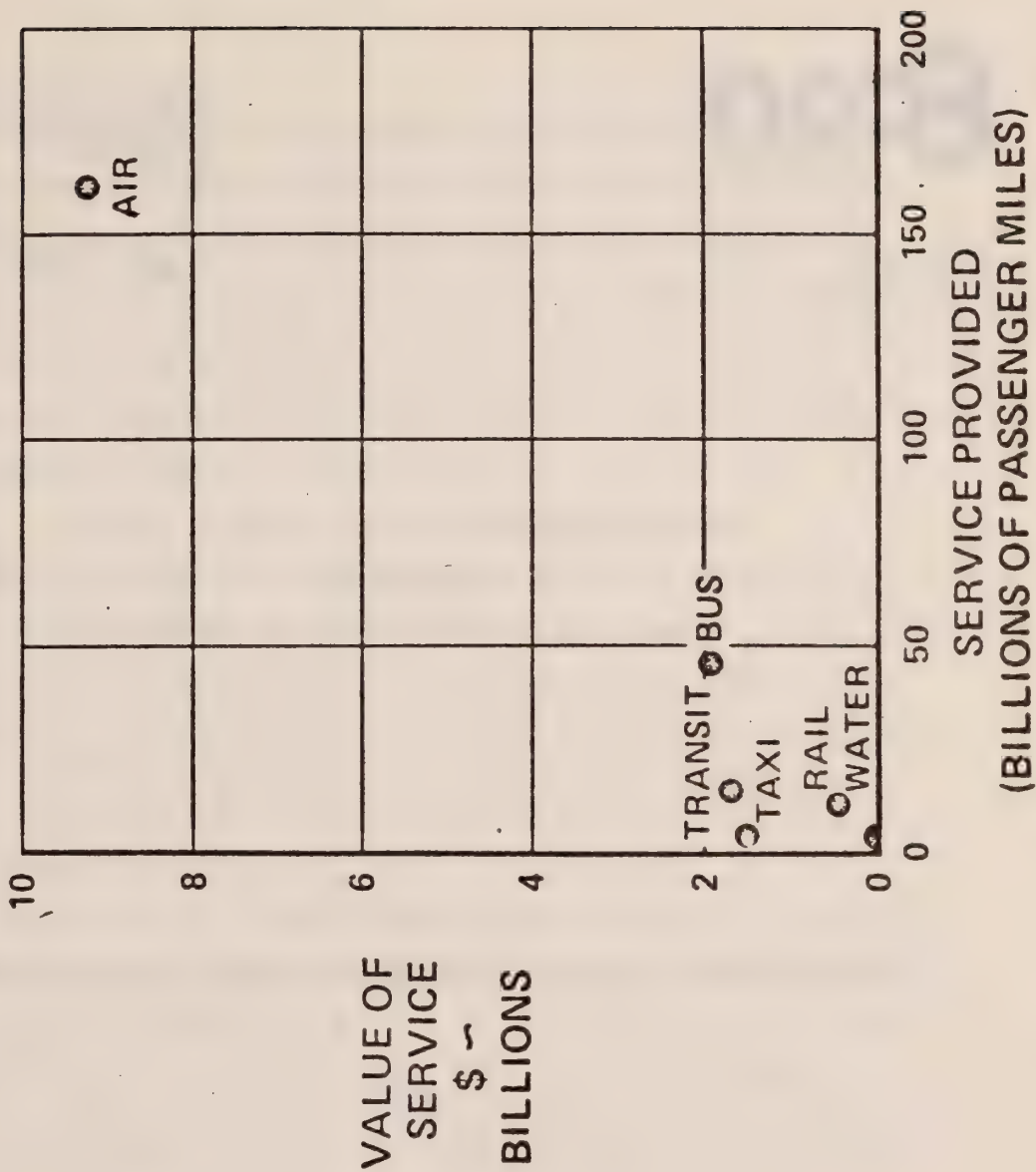
I recognize that I have not followed the outline of your letter and that I have necessarily been quite general, but I hope that I have adequately expressed my conviction that help is needed to use our technology - otherwise the source of this technology will dry up. I thank you for your continuing concern and hope that somehow you can help to remove the restraints that are keeping us from doing our best.

Very sincerely yours,

A handwritten signature in dark ink, appearing to read "Willis M. Hawkins". The signature is fluid and cursive, with a large, stylized initial 'W'.

Willis M. Hawkins

**FOR-HIRE
PASSENGER TRANSPORTATION
PROVIDED BY U.S. CARRIERS**
1970





NINE HUNDRED STATE ROAD
PRINCETON, NEW JERSEY 08540
609 924-8778

KLAUS P. HEISS
President

MAY 14 1976

Written Statement of Dr. Klaus P. Heiss
President
ECON, Inc., Princeton, New Jersey

on

Some Economic Issues affecting the future of Civil Aviation

before the

Subcommittee on Aviation and Transportation Research and Development

of the

Committee on Science and Technology, U. S. House of Representatives

ECONOMICS OPERATIONS RESEARCH SYSTEMS ANALYSIS POLICY STUDIES TECHNOLOGY ASSESSMENT

Thank you very much for your kind invitation to present my views on some economic issues that will affect the Future of Civil Aviation in the United States in the next decade. As you know over the past ten years I have been deeply involved in some major programs affecting aeronautics and astronautics, research and development activities of the civilian United States space and aviation programs.

The substance of my testimony is based on three principal studies I was involved in over the past two years: first, a study by ECON for the National Aeronautical and Space Administration on "An Assessment of the Benefits of the Use of NASA Developed Fuel Conservative Technology in the United States Commercial Aircraft Fleet", Princeton, New Jersey, August 1975; second, a study for Aerospace Industries Association on "Aerospace Capital Formation: Impact of Inflation and Depreciation", Washington, D. C., April 1976 and third, a more academic treatment of longer term questions I was involved in with two colleagues of mine in "Long Term Projections of Power: Political, Economic and Military Forecasting", Ballinger Publishing Company, 1973. In addition the subsequent testimony also draws upon a statement I was invited to make to the Democratic Platform Committee on May 1, 1976 in Denver as a spokesman for the American Institute of Astronautics and Aeronautics, a statement that will

be submitted hopefully in identical wording and form also to the Republican Platform Committee. I believe the subsequent observations as well as those contained in the presentation to the Democratic Platform Committee to be independent of any particular political leaning or preference: rather, I believe the issue of research and technology to go to the heart of any efficient United States economic system, particularly over the next decades when the United States will have to increasingly compete with other regions in world markets on an increasingly equal footing.

The subsequent testimony is ordered into the following broad sections:

First, I will touch upon a brief summary of the factors of production and constituents of United States economic power.

Second, I will review the current state of U. S. research and development activities.

Third, the economic importance of national research and development will be reviewed.

Fourth, aspects of an active aircraft research and development program will be listed, with particular emphasis on fuel conservative research and technology and,

Fifth, most important, I will touch upon some empirical findings as to the erosive effect inflation, current taxation and accounting procedures, as well as government procurement and price regulation procedures have on capital formation in aerospace industry. This last point I believe to divert the most immediate and important attention of this committee not just in the context of civil aviation but overall in the context of civilian research and technology across all sectors of the United States economy. With an erosion of the capital and liquidity base of American, free market and private enterprise industry the demand for innovation, new technologies, and equipment incorporating such new technologies is undermined, and thereby the future competitive position of the United States economy, both domestic and international.

1.0 Factors of Production and Constituents of United States Economic Power

Few people in the history of economic thought can be said to have had a real, profound understanding of the workings of economic systems and the role of capital, labor and knowledge - i.e., both human capital and technology. This may be a surprising statement to non economists. It is only presented here to excuse the other observation that the public at large is even more confounded by the working of economic systems and the often confusing and contradictory statements they have read on economic matters.

To state a very recent example: a headline in the business and finance section of the New York Times of Friday, November 7, 1975, as well as Business Week, reported capital outlays to rise in 1976 and total projected spending on new plant renovations and equipment to total \$123.45 billion (obviously a "large" number - and accurate to five digits). The first and second paragraph of the same article expanded on this information, explaining that the \$123.45 billion constituted a 9% rise over 1975. In fact, however, the truth worth reporting was buried in paragraph 4: *"According to present plans capital goods industries will deliver the same number of units of equipment and construction in 1976 as in 1975. For the manufacturing industries, the 1976 change in physical volume of investment works out to be about a one percent decline"*.¹ While the headline and subtitles proclaim dramatic increases in capital outlays, in fact (that is) in constant dollars) capital expenditures stay constant or, worse, decline. A casual reader (and I classify many economic advisors among these) will be confirmed in their belief that "things are getting better," whereas, in fact, they are not.

Moreover, the true essence of capital embodies time, both past and future. In trying to maintain the existence of a given

¹Quote exact with exception of underlining to indicate emphasis by this author.

amount of capital equipment, replacement expenditures are incurred. When final account is taken of the impact of these constant dollar expenditures, the decline of one percent in physical investment will translate into a much more severe decline in capital formation and it is this erosion of the capital stock which is causing the economic system to stagnate today, in my opinion.

It is the hypothesis of these remarks, and my concerns, that real capital is one of the important determinants of the health and growth of any economy - of future profits, employment and innovations - and that this stock of capital is being gradually eroded by inflation through the United States accounting and tax systems.

Real capital formation needs to be reinstated as the cornerstone of economic growth, and as the basis for the demand for new technology assets, and can only regain that status if the illusion of historical cost accounting is recognized as a destroyer of capital in periods of continuing inflation.

In order to examine the impact inflation has already had on capital formation in the private sector, 50 U. S. corporations were examined by ECON, among them all significant companies that

did aerospace work in the 1965-1974 period. To assess the impact of inflation on these corporations in the future, alternative levels of inflation, 5, 7.5 and 10 percent, were assumed and applied to the analysis of projected corporate performance, by company, over the next decade (1975 to 1984). But before presenting the corporate case study approach and its results - in the last part of this statement - a few explanations on the workings of economic systems, and why the distortion introduced by inflation on capital formation has serious effects on the United States economic system (and other economies of the Western World), are necessary.

Primary Resources, Labor, Capital and Know-How

While there are many ways of grouping and classifying the production resources of an economic system, all include some division of the factors of production into the four following categories:

- (a) Primary resources in the form of raw materials, land, climate and location are items with which nations are variously endowed but which are given, often fixed, constraints. The United States is quite fortunate in this constituent of economic wealth and compares at roughly equivalent levels with the Soviet Union and China, and somewhat better than Western Europe and Japan.

(b) Labor, in the form of people employed or potentially employable, is a function of population size and ability (legal or cultural) to work. The United States has a lower population than Western Europe and the Soviet Union and, in numbers, only one-quarter of China's population. In addition, the United States population experiences considerable delay of entry into the active labor force due to the length of customary education and a relatively early exit. The work week in the United States is shorter than in any other major region under consideration. Finally, over 50% of the United States labor force is employed in service occupations while a higher degree of service satisfaction is not apparent. However, on the other hand a much larger percentage of the labor force is employed in agriculture in the USSR and China than in the United States (25, 80 and 4 percent respectively).

(c) Capital in the form of plants, machinery, equipment, transportation and communications

(b) networks has been the source of the dramatic rise of European economies and the Western Hemisphere. It is this factor of production and wealth that supposedly makes the United States and other Western economies "capitalist" countries versus more agrarian or pastoral systems. Of course the term "capitalist" is also used to denote the form of ownership and risk of initiative and decision-making. Where it lies with private persons, individuals, or companies motivated by their own gain (return above costs, including risk and interest), one labels it "capitalist"; where it is controlled (owned or decided) by society, one labels it "socialist".

One of the essential elements of management decisions is the ability to commit, and the commitment, of capital resources. In order to display true preferences, the decision-maker, whether it be individual or firm, must be committing his own capital. For instance, he may tend to take more (or less) risks if the capital is not his and he feels that he has nothing to lose if the venture fails. This occurs in much the same way that a consumer may be willing to pay more than normal for goods

if the money he is using is not his own (e.g., expense accounts in large firms where the employee owns no stock or profit sharing). If capital is not available, the private enterprise is unable to make new investments or ventures. If it obtains capital from the government, the investment decisions are transferred to government bureaucracies. If channels do not exist to handle such commitments, investment decisions can not be made.

It is the (historical) endowment of the United States with capital that has assured this country its dominant role in the 20th century. Thus, if we believe that free enterprise is essential to continue the historic expansion and success of the United States economy, the question of whether and how much private capital is available at anytime is a fundamental issue. For aerospace industries very specific, concrete numbers are now available for Congress to take positive correct action.

- (d) R&D or Know-how, either in the form of an educated labor force (human capital) or of technology embodied in capital (advanced machinery, transportation systems, communication and process devices).

This has probably been the other of the two major sources of wealth and power to the United States, particularly since 1945. For example, in an econometric study by ECON of the United States telecommunications sector, it has been shown that from 1947-1970 technical innovation generated substantially more than 50% of the total increase in telecommunication services (households and businesses) making this by far the primary factor of increased production (capital ranked second while the contribution of the labor component was minor). United States dominance in this area has been well recognized. Western Europe and Japan have made tremendous progress during the late 60s and 70s while the Soviet Union has had less success in this area. Six observations are appropriate, however:

- (d1) Technology has to be "embodied" in capital (equipment, plants, machinery, processes). Knowledge by itself is of little use, as demonstrated in many developing countries. Thus, if the capital base stagnates or vanishes, so will the ability to innovate.
- (d2) Know-how is not "containable", that is, to a particular region, race, religion or nationality. Any one of these attributes can temporarily be a strong motivating

factor, but the emphasis ought to be on "temporarily". Nor can it be "protected" for any length of time. The present efforts by China to induce a spirit of innovation, an urge to learn at all and any levels however simple, may seem amusing to many an outsider, but the long term impact, if sustained, will be profound.

(d3) Research and development activities in the United States, in terms of expenditures or manpower, have been decreasing in the past decade, while the relative efforts of other regions such as Western Europe and Japan, China and the Soviet Union have been substantially increased. This is particularly true if one limits the research and development to purely civilian and economic needs - a difficult and probably questionable restriction.

(d4) The United States uniquely benefited in the past forty years from a one-time inflow of highly qualified scientists and technicians. This source of know-how has ceased and may in some instances have been reversed.

(d5) There are indications that the "marginal returns" to further education efforts are diminishing and may now be negligible; in some instances there may be evidence of actually declining levels of educational achievements in elementary and high schools as well as colleges.

(d6) Finally, there may be limits to what can be economically known and thus to innovation. This concern has been profoundly expressed by Joseph Schumpeter in 1942 (Capitalism, Socialism and Democracy, Harper and Brothers) wrongly then, as it turned out, and lately again by Wiesner of the Massachusetts Institute of Technology.

If these observations hold, then this distinguished source of economic wealth of the United States may be constrained in the next decade.

If one were to agree with the broad observations on the above four factors (constituents) of economic wealth and power, one would then have to agree that capital formation and technical innovation are inextricably linked and that these two factors are the major variables which have given the United States the dominance it now enjoys.

If the capital base of the United States economy were stagnating or in fact eroding, the United States economy will stagnate and economic innovation in private enterprise will cease. Thus, the question of what capital formation is, has been and will be, is fundamental to the economic condition of the United States.

Before proceeding to the next issues in this presentation, I would like to point to one overriding important distinction, that between monetary and real capital.

In the minds of the public and also of some economists; the term capital denotes, interchangeably, wealth, possessions, money, plant and equipment. However, in the context of capital and capital formation in an economic system, two fundamentally different terms of "capital" have to be distinguished:

- (a) Real capital denotes physical goods in the form of machinery, plant and equipment. These are used with labor to produce goods and services; since these items are quite often used beyond a single accounting period, say one year, the term durable goods is often used synonymously for real (production) capital.

- (b) Monetary capital denotes simply any accumulation of paper bills (or entries on banking accounts) which give one purchasing power or the potential title to dispose of resources (labor, equipment, plant, consumer goods).

Even though in market economies, except in times of crisis, monetary capital can readily be exchanged into real capital (through purchases), the two terms are strictly different. When account entries cannot be exchanged into paper bills and paper bills cannot be "exchanged" into goods and services, in particular, capital goods or real capital, one discovers the crucial distinction between real capital and monetary capital.

In addition, monetary capital can instantly be transferred worldwide at little cost. On the other hand, real capital in the form of equipment, plants, transport fleets, and networks may take months, years or decades to transfer, and some forms of real capital, such as interstate highways and other "fixed" investments, can never be transferred. The distinction is most apparent today in the OPEC countries. While highly endowed with financial capital amounting to billions of dollars, it is extremely difficult, if not impossible for them to obtain real capital within their boundaries. During the years in which this transfer of real capital is taking place, they hold only paper or account entries.

These distinctions, the process between monetary and real capital, are emphasized because of its importance to understanding real capital formation in any economic system, and any economic sector, particularly the Aerospace sector: monetary savings in an economic system is not the same as real capital. Real capital is formed only if new plants and equipment are produced, procured and put to productive use. While accumulation of monetary capital can be equated with savings, there is no reason why such savings must lead to the creation of real capital (an assumption all too readily made by macro-economists). Most obvious to people who do understand these matters from long personal experience, such as the excellent statement made to this Committee by Dr. Edgar M. Cortright and Dr. Jerry Grey, is the fact that no amount of monetary savings assure one of an instant and competitive aerospace industry and technology. That basis takes years and decades to nurture and cultivate.

Furthermore, such monetary savings may be diverted into the public sector and may be used instead for defense expenditures, local, state or federal government services or lost by inefficiencies in nonmarket services. As a matter of fact, it is quite feasible, and indeed happening, that monetary savings (forced through inflation or voluntarily) are directly expended in government service expenditures without noticeably

increasing services delivered. Yet most macro-economic models since John Maynard Keynes have been built on the assumption that the balance between monetary savings and real capital formation is somehow automatic. Not so:

A favorite example of mine to the contrary, with an "apparent" infinite capital formation opportunity and guaranteed full employment, is the "circular hole concept". The concept originated from missile silo emplacements. Machinery, labor and know-how are needed in the production of an "ideal" circular hole. A "circular" hole is perfect to solve the waste disposal problem as well as possible limitations to land resources. With an "accumulation" of circular hole "assets" on national income accounts, it is possible to expend any amount of monetary savings in an economic system without one dollar of real, i.e., productive, capital being formed. The labor expended in drilling a circular hole is accumulated on books as capital - the waste is disposed within the hole itself - other than the initial volume need for work. As unemployment in the rest of the economy increases, the number of circular holes are defined to be capital, the savings needed in the rest of the economic system have to equate the real capital formed - in circular holes. While macro-economists accumulating data for National Income Accounts would be overjoyed with the ensuing statistics, the state of the economy would

would be left where it was before. (Lately city governments seem quite successful in imitating the function of "circular holes".)

2.0 The Current State of U. S. Research and Development Activities

Aside from real capital formation in industry, and in the aerospace sector in particular - a topic I will return to at the end of my testimony - the other major factor of U. S. strength - and concern today - is the national effort dedicated - to providing new ideas and technology, that is the sciences, research and development activities of our society.

At a recent meeting (July 15, 1975) of the Joint Economic Committee's Subcommittee on Economic Growth, the Honorable Chairman Lloyd Bentsen noted that:

"The United States has no apparent national policy for encouraging basic research, or for stimulating the kind of technological innovation that is needed to build and maintain a healthy growing economy. Federal funding of research and development, which makes up more than half of the national total, grew by 5.6% in real terms (that is, in constant dollars) between 1961 and 1967, but since then has actually declined by 3% per year....a 21.5% decline (1967 to 1975). The 1975 amount is smaller in real terms than for any year since 1973.

"We have dismantled our cold war research apparatus, and have failed to replace it with one directed toward our new national needs -- economic growth, environmental soundness, export competitiveness, and social welfare."

At the same hearings, Dr. Jacob Rabinow of the National Bureau of Standards said.

"There are three ways in which a country can become rich and improve its standard of living. One, of course, is to be literally floating on a sea of gold or oil...The second way is to rob somebody else...You get a colony and make them work for you. This has been classic for many hundreds of years, but it is getting difficult; for us, it is impossible. The third way, and the only way left by which we can improve our standard of living, is to improve the technology; that is, for every hour of work of a man or woman to produce more bread, shoes, TV sets, whatever we like, and to produce more services. This means technology has to be supported and there is no other way."

A new direction and commitment is needed in this country in pursuit of a strong Federal Research and Development Program geared to meet the human, social and economic needs of this country within the next decades. This new direction becomes all the more important if we note the recent findings of the National Science Boards

- (1) Total national R&D expenditures stagnated between 1968 and 1974 at \$22 - \$23 billion (constant); from 1960 to 1968 they increased every year.
- (2) The total employment of scientists and engineers reached its peak in 1969 at 558,000. In 1974 this employment was reduced to 528,000, despite the increase in the total labor force.

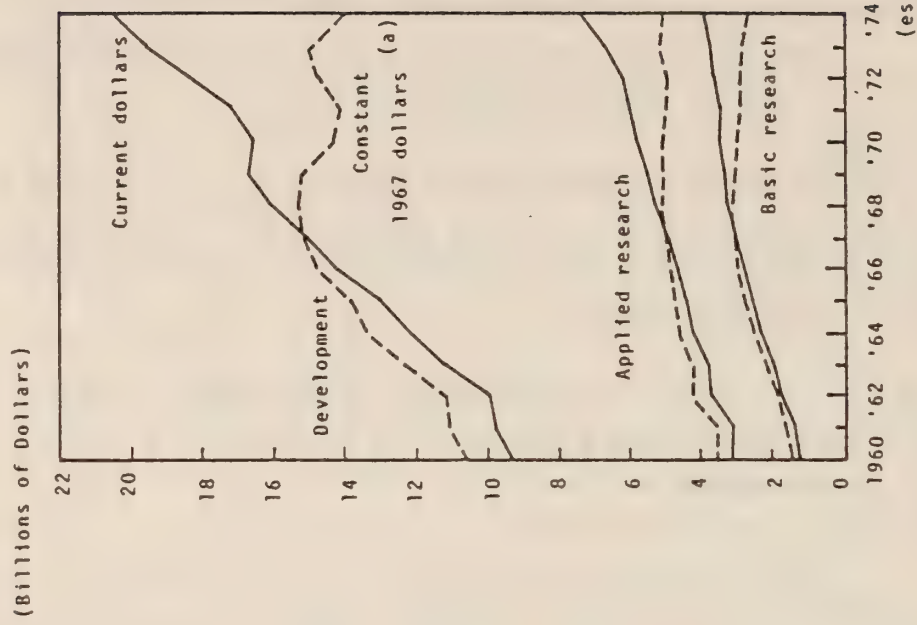
- (3) In 1964 the United States spent 3% of its GNP on research and development. In 1974 the United States spent only 2.3% of GNP on such activities. Federal funding dropped from 2% to 1.2% of GNP.
- (4) Federal funding of R&D reached a high in 1966 and dropped since then by 20%. In 1974 funding of R&D was \$12 billion (constant) less than the 1963 funding level.
- (5) R&D funds as part of the total federal budget have fallen from a high of 13% in 1965 to a low of 7% in 1974.

This stagnation and recession in the national - and even more so in the federal - science and technology effort is illustrated in Figures 1 and 2. The single most important cause in this slackening of support for the national R&D effort is the "benign neglect" on part of the federal government ever since 1968.

New signs are emerging that priority for industrial R&D is decreasing. Moreover, this is the only other significant source of research and development funding (about 1% of the GNP).

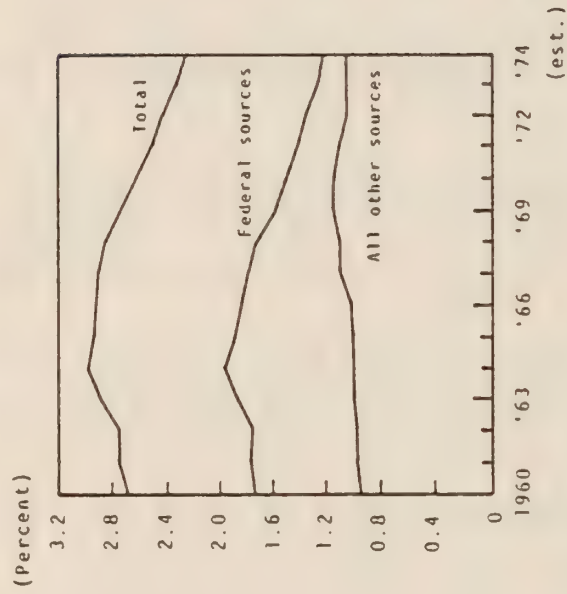
As stated in an article titled "R&D Is Losing Its High Priority", which appeared in the May 12, 1975 issue of Business Week, "Many companies are shifting their research goals. 44% of the manufacturers surveyed said their main R&D goal was to improve existing products. As a result, development of new products seems to be slowing. By 1976, only 13% of industry sales will be new products, down from the 18% that the industry

National R&D Expenditures by Character of Work, 1960-74



(a) CNP implicit price deflators used to convert current dollars to constant 1967 dollars.
SOURCE: National Science Foundation

National R&D Expenditures as a Percent of GNP, by Source, 1960-74



SOURCE: National Science Foundation

Figures 1 and 2

expected for 1975. In short, companies now seem less willing to gamble on new products...73% of manufacturers said they did not anticipate a 'technological or basic research breakthrough' by 1975. The danger, of course, is that companies striving for near-term profit may be sacrificing long-term potential...It may mean a lower growth rate in years to come."

BASED ON THE ABOVE, THE UNITED STATES NEEDS A RENEWED, FORCEFUL COMMITMENT TO RESEARCH AND DEVELOPMENT, TO SCIENCE AND TECHNOLOGY TO MEET HUMAN, SOCIAL, ECONOMIC, AND NATIONAL SECURITY NEEDS.

3.0 The Importance of National Research and Development

As to the benefits of a vigorous research and development policy erudite economic studies have been performed which demonstrate that a small amount of "seed money" in advanced research and technology bears rich fruit in its effect on national well-being.

The most authoritative quantitative studies on this issue go back to the early part of this century - the foremost investigation being J. Schumpeter, the famous Austrian economist at Harvard and in the early fifties by Messrs. Harrod, Domar, Solow and Hicks.

Efforts to estimate the public and private rates of return to investment in R&D have yielded impressively high figures - confirming many of our intuitive beliefs that indeed science and technology are crucial to the well-being of the United States and their position in the world economy. In his presidential address delivered at the 1969 meeting of the American Economic Association,

W. Fellner (1970) found that "the present average social rate of return from the progress-activities is substantially in excess of 13 percent on the all inclusive cost-base, and substantially in excess of 18 percent on the cost base limited to institutionally profit-oriented progress inputs".

In the U. S. Communications industry - a high technology industry - K. H. Young (1973) found the same rate of return to be in excess of 25 percent, compared to that of capital and labor (less than 10 percent).

In agriculture F. Grilliches (1964) concluded that the rate of return to R&D in agriculture was extremely high when studying farm production and the amount of land, labor, fertilizer, machinery as well as expenditures for research and development.

Similarly, a study of Chase Econometric Associates indicates that a \$1 billion increase in the space program (NASA) would generate by 1985 a \$23 billion increase in GNP.

NASA is used here, incidentally, only as being typical of an advanced technology agency; similar results would have been found for ERDA, DOT, NSF, or others, provided only that the funding was used for advanced technology. These are the measurable benefits at the national level; other benefits, about which I will speak in a moment, could be even more significant.

There are, of course, economists who question the specific quantitative conclusions of studies like the ones I have cited. But even if the forecasts were reduced by half -- or even more -- the conclusion is inescapable: R&D is an essential element in national economic growth and, economic growth is desperately

needed to solve the pressing national problems we're all so familiar with. So why has this area - crucially important to the future of the United States - not received the attention it deserves? Does the United States need another visible crisis to be "shocked" into a recognition of this problem?

Despite the promising projections of the econometric analyses perhaps this Committee, and, I'm sure, many other concerned people both within and outside the federal government, may still think of this as special pleading for a renaissance in a field that one might consider too luxurious for the country in these days of high unemployment and high costs. However, that is not the case. The above considerations are true for all research and development in the United States.

The decline of the United States commitment to science and technology, and to the use of that technology, is best illustrated in the slackening commitment to aeronautics, astronautics, and space exploration in this nation - the main motivating factor of civilian R&D in the 1960s. Let's look at this past. NASA's budget for example as representative of research and advanced technology in the United States has been dropping (in real constant dollar terms) for the past ten years and so has relative U. S. productivity. I think that's not just a coincidence as other areas in federal research and development have suffered from similar "benign neglect". Between 1967 and 1975 the productivity growth rate in this country was 1.3% -- less than half of what it had been in the eight year period prior to that when NASA's budget - and those of federal R&D in general were increasing. Some specific examples of what this means are given:

o Aviation, the "hero" of the United States manufactured-product export trade, with \$6 billion in commercial exports last year, is being allowed to founder by an almost incredibly short-sighted approach to aeronautical research and technology. There's not a single major civil aeronautical development underway in the United States today, although over 90%, in dollar value, of the free world commercial aircraft are U. S. made. We are going to lose that market. In 1965 we had 80% of the helicopter market, today we have 40%.

The decline of the United States in this area can also be seen from the decrease in employment in aerospace industry; by the end of this year employment will drop another 3.5% to a work force of just under 893,000, its lowest absolute point since 1960! The reasons for this drop are among others (1) uncertainties in export markets; (2) a reduced federal commitment to military aircraft; and, (3) a reduced investment in the space program. The hardest hit regions are the west, north, central regions of the United States - a drop of 8.9% in employment. How can the unemployment of these most valuable human capital resources contribute to a healthy and vigorous U. S. economy?

To make matters worse under present U. S. accounting procedures where depreciation costs are based on historical acquisition cost rather than current market prices, there exists continual erosion of the capital base of U. S. industry. It is

the cojoining of human labor with efficient equipment that makes the labor force productive. Unfortunately today the real productivity of labor is increasing substantially less in the United States than in other major industrial nations and would according to efficiency principles dictate a falling of the relative position of the United States. The effects of the present accounting rules coupled with inflation is generating false signals to both capital and labor groups and hence the nation is showing the symptoms of increasing prices, unemployment and an aging capital stock. New productive capital will make possible higher wage rates, more employment and higher economic growth which is the commitment made by Congress in the Full Employment Act of 1946. Without proper incentives for capital accumulation the U. S. economy will continue to stagnate. For example, in the past ten years AEROSPACE INDUSTRY alone understated depreciation costs by over \$1 billion dollars. Over the next ten years the same erosion will increase to between \$4 to \$5 billion at the 5% inflation rate, and it is this erosion alone that will be sufficient to guarantee continued stagnation and high unemployment in this industry. IN OTHER INDUSTRIES SUCH AS TRANSPORTATION, MACHINE BUILDING, STEEL INDUSTRY THESE EFFECTS ARE EQUALLY PRONOUNCED, DRAMATIC and ADVERSE.

To maintain a strong U. S. economy and U. S. export sales, and to make them grow, we need a healthy program in aeronautical R&D and space exploration in at least the same proportion to gross sales as was the aeronautical R&D program which first built this market for us.

But, just spending money on any R&D is not sufficient; the goals and purpose of R&D ought to lead to concrete benefits to the nation and to society in areas such as national security, global resources information and monitoring, transportation, energy uses, health care, education. In the next section a few such goals are suggested.

4.0 The Fuel Conservative Aircraft R&D Program: A Case Study

Drs. Edgar M. Cortright and Jerry Grey have given in their testimony to this Committee a most comprehensive list of research and development opportunities in civil aviation. The most important points include:

- (1) Short take-off and landing technologies
- (2) Replacement of the many obsolete test facilities dating back to the 1940s and 50s
- (3) Fuel Conservative Aircraft R&D Programs and
- (4) Research toward an economical SST with a passenger capacity of 300 to 400 people, a range of 6-8000 miles, at fuel consumption and noise levels of current subsonic aircraft.

In the following I will report to this Committee the results of an economic study of one of these specific areas. the Fuel Conservative Aircraft R&D programs.

Since the Arab oil embargo in 1973 and the effective cartelization of OPEC oil prices in 1974, the United States government has encouraged serious fuel conservation measures and efforts to reduce dependence upon foreign sources of energy. In response to these national objectives, NASA, in collaboration

with industry, is proposing a research and development program to demonstrate the technology necessary for a new generation of fuel efficient commercial transports.

There exists a 10 to 15 year research and development lead time preceding operational certification for commercial transports. Aircraft in the present fleet were conceived, designed, and produced to balance fuel, maintenance, capital, and labor costs based on design cost parameters that are no longer applicable. In particular, aircraft operating economics have been based on jet fuel prices of 9¢ to 12¢ a gallon. Fuel prices had remained in that range for 20 years prior to 1974. In 1974, however, airline fuel contracts were negotiated reflecting 100% domestic fuel price increases. For U. S. international flights, price increases were 200%.

The purpose of the study by ECON, Inc. was to assess the fuel savings and economic benefits that may evolve from the proposed NASA research and development program. The proposed program has six separate technology elements defined by NASA:

- (a) Engine Component Improvement
- (b) Composite Structures
- (c) Turboprops
- (d) Laminar Flow Control

(e) Fuel Conservative Engine

(f) Fuel Conservative Transport

Two levels of funding were considered: the baseline program is estimated to cost \$490 million over ten years with peak funding in 1980. The Level II Program is estimated to cost an additional \$180 million also over 10 years. Peak funding for the entire program occurs in 1979. Emphasis throughout the program is on implementation of the research in operational aircraft at the earliest possible date. Therefore, items such as maintainability and reliability receive high priority.

The assessment was conducted by evaluating the streams of expected benefits and expected costs (not including industry expenditures) from NASA supported efforts. Since physical shortages of petroleum products have resulted in government intervention in resource allocation mechanisms using complicated allocation formulas, net dollar estimates of benefit streams might not suffice due to the unpredictability of "market prices". Therefore, benefits were measured in both dollar values and in terms of total domestic fuel saved in satisfying the demands for air transportation by United States carriers.

The process of commercial aircraft development is both continuous and incremental. In a given time period, both derivatives of current production aircraft and entirely new designs may be introduced. The need to examine both, derivative models and the new generation of aircraft, incorporating the proposed research and development program implies a planning cycle of 30 years, i.e., to the year 2005. A 30 year planning horizon limits the usefulness and feasibility of methodologies based upon network or city-pair traffic demands and financial flow analyses of individual airlines.

While these "bottom up" approaches (which require large data bases) are necessary for short term planning, in this case, it was necessary to concentrate on aggregate analysis of the entire industry. Therefore, such problems as apparent overcapacity at some points, or whether one airframe manufacturer or a particular airline could finance the development and acquisition of new aircraft, were not addressed. The "top down" approach compared the aircraft fleet that would be in existence without the NASA R&D program with the fleet which results assuming the NASA program is undertaken and the technology is transferred and incorporated into derivative and new generation aircraft.

In order to isolate the interaction between supply and demand factors, the assessment of benefits and costs was made for a given demand structure that was invariant to the NASA research and development program. This approach eliminates the double counting of benefits.

Discussions with NASA and with representatives of the major commercial airframe manufacturers were held to estimate the combinations of the technology elements most likely to be implemented, the potential fuel savings from each combination, and reasonable dates for incorporation of these new aircraft into the fleet. The consensus of these discussions was that, with the NASA program, four fuel conservative aircraft are likely to be introduced before 2000: a short range aircraft in 1987 with 35% fuel savings, a derivative of this model in 1995 with 45% fuel savings, a medium range aircraft in 1990 with 45% fuel savings, and a long range aircraft in 1995 with 45% fuel savings. The short range aircraft would be turboprops with composite materials used for the wing and tail. They would have an improved engine core and several aerodynamic improvements. The medium range aircraft would also be a turbo-prop and would be an all composite structure; it would also incorporate improvements in engine technology and aerodynamic improvements. The long range aircraft would be made of composite materials, would use laminar flow control, and would have a new fuel conservative engine. All four would have active controls.

To estimate the fuel savings for these aircraft, demand for domestic air travel (revenue passenger-miles) was projected through 2005. From an analysis of trends in GNP and yield (average price of air transportation) a growth rate of about 4.2% over this period was estimated. The market for new aircraft was estimated using a fleet inventory model. Key assumptions of an aircraft lifetime of 15 years and load factors of 55% are discussed, and the sensitivity of the results to these parameters is calculated.

Two scenarios were run using these models. The first assumes that the NASA research program is not undertaken and that several evolutionary fuel conservative changes, based on existing technology, are incorporated into derivative aircraft in the early 1980's. Improvement in specific consumption would be about 10%. The second scenario assumes the NASA research program is undertaken and introduces both the derivative aircraft and the new aircraft described above. Fuel savings attributable to the NASA program are the difference between the two scenarios analyzed.

Results for the baseline case (4.2% growth rate) are 90.3 billion gallons of fuel (or approximately 2.15 billion barrels)* will be saved for domestic and U. S. international air operations over

* 1 barrel = 42 gallons (jet fuel)

the 30 year period (1976 - 2005). These results are shown in Figure 3. This is about 21% of the total that would otherwise be used. To put this figure in perspective, the entire United States consumes about 17 million barrels of petroleum products daily for all uses (1974). On an annual basis in 2005, the savings are 9.1 billion gallons per year or about 40% of the fuel that would otherwise be consumed by the U. S. domestic and international commercial aircraft fleet. The figure cited is on the conservative side, since the assumed growth rate (4.2%) is lower than many estimates. The savings grow exponentially with increasing growth rates.

The sensitivity of these results to changes in the parameters was calculated. For example, delay of the entire program for one year reduces fuel savings by about 8 billion cumulatively. On the other hand, acceleration of the entire program by one year increases savings by about the same amount. A shortfall of 5% in achieving the target R&D objectives of reducing specific fuel consumption reduces fuel savings by about 9.5 billion gallons (10%) cumulatively. If the target objectives are surpassed by 5% an additional savings of about 9.5 billion gallons will be obtained. Increasing load factor to 60% decreases fuel savings by about 7.5 billion gallons but the percentage savings remain almost the same. Increasing

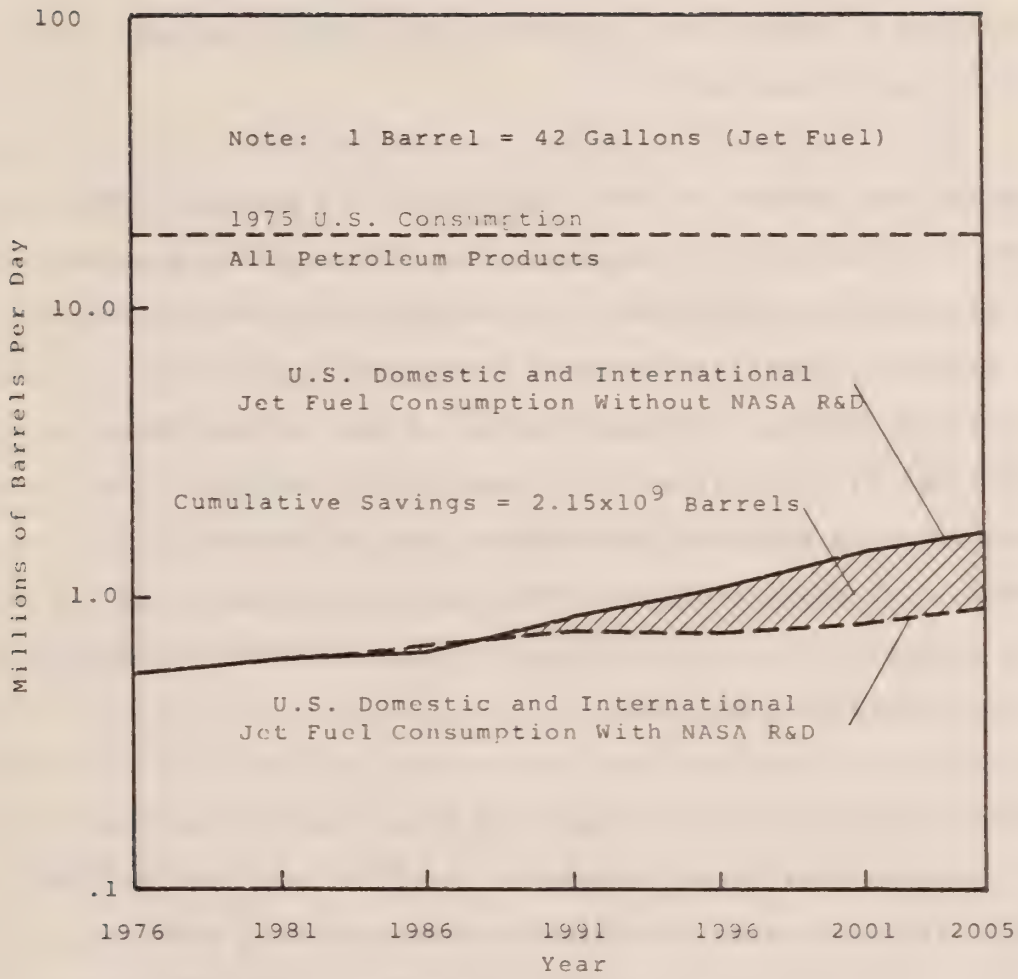


Figure 3 Fuel Used by the U.S. Domestic and International Airtransport Fleet

aircraft lifetime to 20 years reduces fuel savings by about 12.5 billion gallons. However, fuel consumption without the NASA program is higher and, therefore, the savings become relatively more important.

To compare the savings in fuel requirements in the late 1980s and the 1990s to the program costs from 1976 to 1985, discount rates of 10% and 5% were used. In the most conservative case U. S. jet fuel prices were assumed to remain constant at 22 cents per gallon; the present value of the savings then is \$2.7 billion (\$ 1975) at a 10% discount rate, compared to a present value of the NASA R&D program costs of \$425 million (\$ 1975). The payback date is 1990. With a discount rate of 5% the present value of the savings is \$6.4 billion (\$ 1975) and the payback date is 1989.

Alternatively, if fuel costs escalate at a rate of 7% a year, then the present value of the savings is \$11.7 billion (\$ 1975) at a 10% discount rate. The payback date is 1987. With a discount rate of 5% and an escalation of fuel costs of 2%, the present value of the savings is \$14.4 billion (\$ 1975). The payback date remains 1987.

In summary, within the broad range of alternatives considered the Fuel Conservative Aircraft Technology Program proposed by

NASA promises substantial returns to U. S. society under very conservative assessment criteria.

One final note: The history of technology transfer to the commercial transport fleet has been characterized by the joint application of military and private sector developments.* However, since fuel conservation is not a principal mission of the military, it can be expected that the development costs shared in the past by the U. S. government through military funding will have to come from other sources.** Therefore, a gap is developing in the support levels which have historically been available for research and development in this area. This gap can be filled by NASA participation. Without NASA participation, profitability and stockholder preferences of individual firms will be the primary criteria for development efforts. These criteria will not necessarily lead to the same emphasis on fuel conservation, especially where uncertain or divergent views with respect to future pricing and availability of fuel are held.

* Working Group Reports, AIAA Workshop Conference, December 2-4, 1974; The Role of Technology in Commercial Aircraft Policy Formation, AIAA, March 21, 1975, p. 34.

** This possible lack of future "transfer" of military technology to civilian uses has also been strongly emphasized by Drs. Cortright and Grey.

5.0 The Replacement of Old Assets With New Efficient Capital:
A Proposed Initiative

Finally, I come to the heart of my testimony, a proposed significant initiative to turn around the relative decay of the asset and capital base of American industry. In particular, the measure would be aimed to make possible the replacement of obsolete old equipment with modern efficient new technology, not just in aerospace industries but across the board in all of American industry including transportation, machine building, utilities, housing, steel production, car production to mention a few. This proposed initiative is based on the first detailed study of the ten year effects of inflation, depreciation and capital formation for 50 major U. S. corporations, most of them in the aerospace sector. The study was performed by ECON for the Aerospace Industries Association, and was published in April 1976. The results of that study are indicative not just of aerospace but any asset (real capital) intensive sectors of the American economy: the present accounting and tax rules that recognize depreciation only on historical costs, rather than current prices (indexed) leads to the slow gradual erosion of the fixed asset base, leading to a gradual increase in the age of the equipment used and the use of inefficient technologies in producing goods and services in the American system. This is so, since many sectors of the American economy cannot make up through pricing this eroding effect of understating by significant amount the cost of depreciation. For example if industry sells services or goods to the government they are bound by government procurement regulations which only recognize depreciation costs again on historical acquisition prices which then are taken as a base to determine the price (cost) of the service or good. These effects are therefore particularly pronounced where

price regulation or government procurement regulations govern the setting of the prices of goods and services. But in addition it is an issue even in industries where free market forces determined price, since this artificial distortion of understated costs, overstated profits and overstated taxation leads to a heavy penalization of asset intensive sectors of the economy at the expense of activities that use few assets and little capital (for example retail industries, finance corporations, hamburger joints). The study performed for AIA is appended with this testimony. The principal quantitative findings of the study for Aerospace Industry alone were:

- (1) in the period from 1965 to 1974 depreciation was understated, at the actual inflation levels experienced, by over \$1.1 billion.
- (2) aerospace industry paid about \$540 million in corporate income taxes on "artificial" profits due to the understatement of depreciation costs over the same period.
- (3) in the period from 1975 to 1984, even at a 5% level of annual inflation over those ten years, aerospace industry will understate the depreciation costs by another \$3.2 billion and
- (4) overpay corporate income taxes by up to \$1.6 billion due to the same understatement of depreciation costs.

At higher levels of inflation over this decade the same effect would be even more pronounced. Table 1 and Figure 4 summarize the findings for different sectors of industry for the 1965 to 1974 period and for the 1975 to 1984 period for aerospace industry. Other principal findings for the study were:

SUMMARY: TEN YEAR NET PROFITS VERSUS DEPRECIATION ADJUSTMENT
1965-1974 and 1975-1984
(Billions of Dollars)

Industry Sectors	TOTAL Net Profits 1965- 1974	DEPRECIATION ADJUSTMENT			
		Nominal 1965- 1974	Projected 1975-1984		
			5 Percent Inflation	7.5 Percent Inflation	10 Percent Inflation
Aerospace Industry	\$ 6.7	\$ 1.1	\$ 3.2	\$ 4.5	\$ 5.7
Aerospace Companies TOTAL	\$57.4	\$ 9.6	\$24.0	\$32.2	\$43.5
Primarily Aerospace	3.7	.9	2.2	3.0	3.8
Diversified	6.9	1.0	3.5	4.9	6.5
Electronics and Communications	20.0	3.0	7.9	11.3	15.0
Auto and Rubber	26.8	4.7	10.4	14.0	18.2
Other Finance and Retail	\$ 5.7	\$.3	\$ 1.0	\$ 1.4	\$ 1.9

Table 1

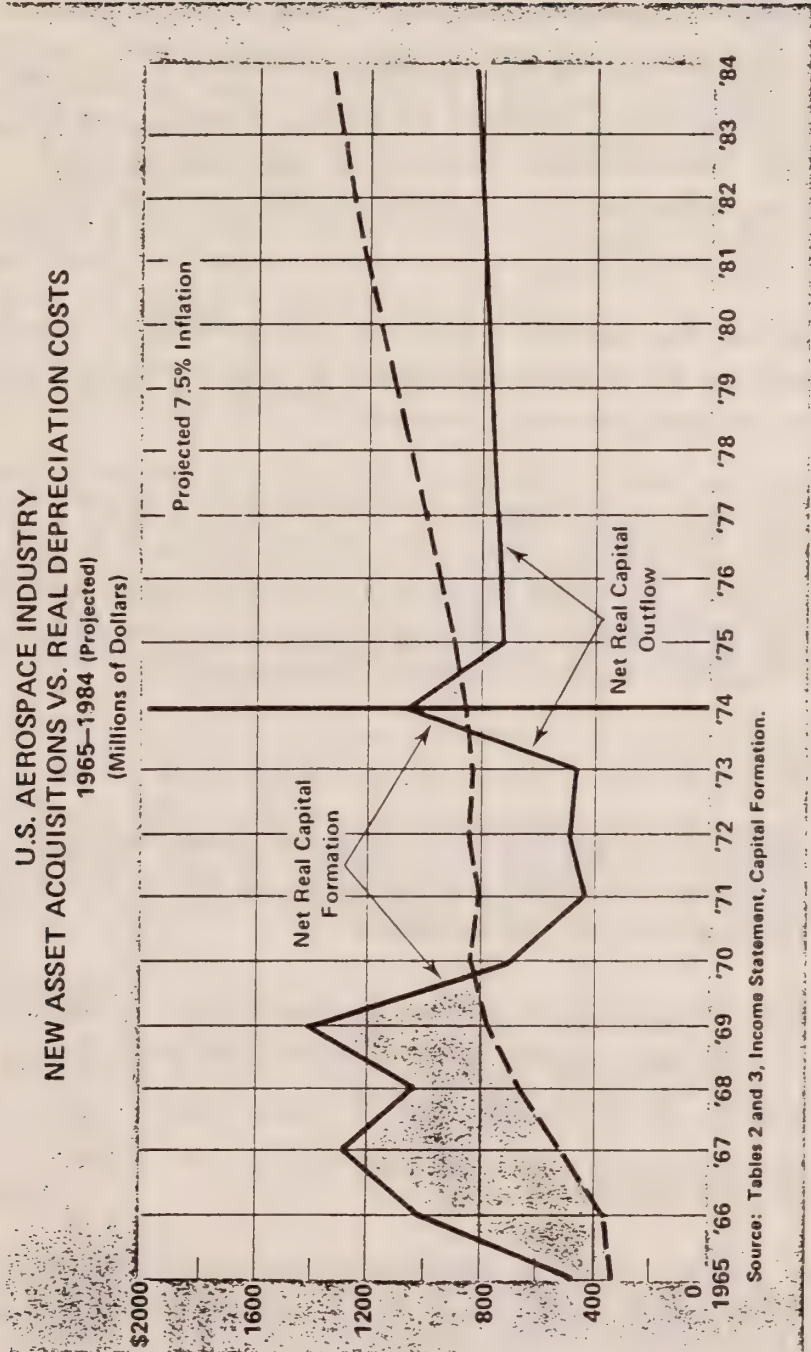


Figure 4

in the aerospace industry:

- o The aerospace industry, and other sectors of the U. S. economy (utilities, transportation, machine building, steel), cannot continue into the 1980s without changes in replacement cost accounting and tax procedures, if inflation persists at levels experienced in recent years.
- o For every dollar of new capital formed in the aerospace industry, one dollar showed up as an understatement of depreciation costs and overpayment of taxes on real profits.
- o While the capital base - and hence technology use - of the U. S. aerospace industry is being eroded, the German base, e.g., is being maintained and supported through accounting practices that ensure a stricter observance of market principles in accounting standards, tax laws and public contract procedures.

the private sector:

- o A significant barrier to achieve the required investments in private industry today is artificial accounting distortions that penalize long-term efficient investments.
- o The issue of debt financing as an offsetting factor is entirely misunderstood: why would banks favor enterprises with future liquidity problems? In fact they do not!

Federal Government Regulations:

- o Clearly, under current U. S. accounting rules, inflation introduces a strong disincentive to any investment of funds in new technology equipment, machinery or other depreciable assets.

- o The current U. S. practice of nominal depreciation is inequitable and causes extensive distortion in the accounting process. Real depreciation, based on reacquisition costs, is a method more firmly founded on economic considerations to insure a correct reflection of market principles and prices.
- o A single price adjustment index issued by the Treasury or Department of Commerce would do - covering 20 to 30 years, to be used on actual age of each asset.

and, for the U. S. economy:

- o When inflation persists over several successive years at rates above 5 percent, the U. S. economic system may become seriously affected by accounting distortion to the point of potential, persistent stagnation, which comes about when gross investments minus real depreciation costs equal zero.
- o If inflation persists, the difference between nominal and real depreciation will have far-reaching effects on capital formation, the incidence of corporate income taxes, government procurement, the performance and liquidity of corporations and, hence, on the long-term outlook for the U. S. economy.

MOST IMPORTANT:

- o Old equipment is not being replaced with efficient modern technology, thus hindering the demand for new technology and R&D. Thereby the normal workings of a market economy are impeded.
- o With real depreciation costs recognized in tax and procurement regulations, U. S. industry will become much more receptive to expansionary economic policies aimed at achieving full employment. Today, the same policies spell ruin to some under inflation.

These findings have received wide national attention. The same issue, of course, exists for all asset intensive companies, such as utilities, steel industry, machine building, transportation and housing.

In conclusion, the most significant initiative that might help new technology industries, and U. S. labor and industry at large, is a single, simple policy measure: to allow depreciation costs of fixed assets to be determined on current market prices rather than historical costs. The German Government procurement rules effective since at least 1953 are appended as a good and simple guide to the correct statement of such legislation.

The effects of such a measure would be widespread and I believe would move this nation a significant step closer to an economy with full employment and low inflation, an economy again capable of meeting the various social and economic needs of this nation including research and development. Economic studies by ECON, Inc. indicate that of the gross investments made by the United States in 1975 of about \$173 billion dollars, depreciation costs based on 1975 prices amounted to about \$183 billion, about \$50 billion more than shown on national income accounts based on historical depreciation costs (see Table 2). Similarly, less pronounced distortions occurred throughout the 1970s.

Table 2

THE IMPACT OF NOMINAL TO REAL DEPRECIATION
ON NET REAL INVESTMENTS

		United States				
		1971 1974				
		(Billions of Dollars)				
R E A L	Gross Investments ^c	1971	1972	1973	1974	1975 ^a
	(-) Real Depreciation ^b	\$153.7	\$179.3	\$209.4	\$209.0	\$173.0
	Net Real Investment ^c	-114.3	-127.6	-141.8	-161.2	-183.0
		39.4	51.7	67.6	46.8	-10.0
Real vs Nominal						
N O M I N A L	Difference	-20.6	-24.7	-31.0	-43.8	-54.1
	Net Nominal Investment ^c	\$ 60.0	\$ 76.4	\$ 98.6	\$ 90.6	\$ 44.1
	(-) Nominal Depreciation ^c	93.7	-102.9	-110.8	-118.4	-128.9
	Gross Investments ^c	153.7	179.3	209.4	209.0	173.0

^aAnnual estimates based on first three quarters 1975
^bAdjustment based on analysis of ten year history of 50 U.S. corporations
^cFrom Department of Commerce, *Business Conditions Digest*, December 1975.

Source: Aerospace Capital Formation, Aerospace Industries Association of America, Inc., April 1976

At the 1975 rate of zero net investment there's no way for this economy to move upwards again toward full employment, and industry cannot possibly make the investments needed to assure such full employment. Once the liquidity in industry exists to make new investments, the demand for new technology, research and development will again pick up and guarantee a better use if not full development and employment of the scientists and engineers of this nation.

Finally, with equitable accounting procedures restored, U. S. industry may become once more receptive to expansionary economic policies to assure full employment. I know of no single cause that could be more important to the future of the United States in the decades ahead, the health of its industry and the demand - once again - for new efficient assets, technology and, thereby science, research and development.

Appendix

Appendix A German Government Rules

Appendix B AIA Aerospace Capital Formation

APPENDIX 2: GERMAN GOVERNMENT DEPRECIATION
COST PRINCIPLES AND PROCEDURES

The following material contains German Cost Principles as described in Regulation PR/NO 30/53 on Pricing in Public Contracts, as presented in November 1953 and revised in November 1961 and December 1967.

Depreciation of Fixed Assets37. Definition

- (1) Depreciation of fixed assets is a cost arising from the reduction in the value of fixed assets required in the contractor's operations.
- (2) The depreciation charge may be determined per unit of time or per unit of output (ton, unit, machine-hour, etc.).

38. Depreciation Charge and Valuation Method

- (1) The depreciation charge will be determined independently of the asset values stated in the balance sheet and in tax statements. It is obtained by evenly spreading the cost of acquisition or manufacture of an asset over its useful life. Installation and startup costs are part of the cost of acquisition or manufacture.
- (2) Where the cost of acquisition or manufacture differs substantially from replacement cost, and this is not only a temporary development, and provided that the principle of valuation at replacement cost is consistently adhered to, depreciation charges may be calculated on the basis of
 - a) the cost of acquisition of an equivalent asset at the date specified in subparagraph (3) below instead of the actual cost of acquisition of the asset;

- b) the cost of manufacture of an equivalent asset at the date specified in subparagraph (3) below instead of the actual cost of manufacture of the asset.

(3) The following reference dates will be used in determining replacement cost:

- a) where assets were already in use on 20 June 1948, either 30 August 1948 or 30 August 1949, for whichever date replacement cost is lower;
- b) where assets were acquired after 20 June 1948, the valuation date.

(4) Where the lower of the two values referred to in subparagraph (3)a) above cannot be derived directly from the records, it may be determined by a careful estimate taking the higher value as a reference.

39. Useful Life

- (1) The useful life of an asset may be expressed as the normal life expectancy of this kind of asset or its estimated output over its expected physical life.
- (2) The estimates of the useful lives of assets or groups of identical assets will be periodically reviewed. Where depreciation charges are found to have been excessive or insufficient, they will be charged or credited, as appropriate, to depreciation contingencies subject to the provisions of paragraphs 49(3) and 50 below. The contracting public agency and the contractor may agree otherwise.
- (3) Where the elapsed portion of the useful life of an

asset cannot be clearly determined, its estimated residual value (value as new at current prices less past depreciation) may be used as a basis for computing the depreciation charge.

40. Adjustment of Replacement Value

Where the replacement value of an asset (according to paragraph 38(2) above) is used as a basis for determining the depreciation charge, this replacement value will be adjusted to reflect the reduced efficiency of the actual asset as compared with that of an equivalent replacement asset.

41. Special Depreciation Charges

Depreciation charges (according to paragraphs 38 to 40 above) may be exceeded to make allowance for an unforeseeable technological development, shift in demand or for other reasons (special depreciation charges), provided that the contracting public agency expressly agrees to such higher depreciation charges. Special depreciation charges (according to the first sentence of this paragraph) will be disclosed separately.

42. Records of Fixed Assets

(1) Records of all fixed assets will be maintained containing all data relevant to depreciation, in particular initial values, estimated useful lives,

useful life elapsed to date, depreciation charges per unit of time or output and residual values.

- (2) A separate record will be maintained for each individual asset, provided, however, that identical assets of identical initial value or of low value may be grouped together.
- (3) Where the contracting public agency so requests, the contractor will substantiate replacement values (according to paragraph 38(2) above) and adjustments computed according to paragraph 40 above.



AEROSPACE CAPITAL FORMATION

Impact of Inflation and Depreciation

Volume I, Executive Summary

AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.

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The mission of the Aerospace Research Center is to engage in research, analyses and advanced studies designed to bring perspective to the issues, problems and policies which affect the industry and, due to its broad involvement in our society, affect the nation itself. The objectives of the Center's studies are to improve understanding of complex subject matter, to contribute to the search for more effective government-industry relationships and to expand knowledge of aerospace capabilities that contribute to the social, technological and economic well being of the nation.

CONTENTS

	Page
INTRODUCTION	5
SUMMARY	6
1. Depreciation, Capital Formation and Inflation: Nominal vs. Real Depreciation.	9
2. Aerospace Industry Results.	12
3. Accounting Distortion at The National Level	20
4. Recommendation	22
 TABLES	
1. Financial History of a Capital Asset	10
2. Analysis of Nominal Versus Real Capital Formation.	14
3. Analysis of Projected Versus Real Capital Formation	15
4. Summary: Ten Year Net Profits Versus Depreciation Adjustment	20
5. The Impact of Nominal to Real Depreciation on Net Real Investments	23
 FIGURES	
1. Inflation Accounting Effects on Aerospace Capital Costs, 1965-1974.	7
2. Estimated Accounting Effects on Aerospace Capital Costs, Depreciation and Corporate Income Tax, 1975-1984	8
3. Example of Current Accounting Procedures for Funding New Capital Acquisitions	9
4. Example of Real Cost Accounting Procedures for Funding New Capital Acquisitions	12
5. U.S. Aerospace Industry Capital Age Structure	13
6. U.S. Aerospace Industry Nominal vs Real Net Capital Formation	16
7. U.S. Aerospace Industry Nominal vs Real Depreciation Costs	17
8. U.S. Aerospace Industry Liquidity Impact of Accounting Distortion.	18
9. Estimated Range of Depreciation Adjustment As a Percent of Nominal Earnings	19
10. U.S. Aerospace Industry New Asset Acquisitions vs Real Depreciation Costs	21
11. Accounting Distortion Effects Based on Fifty Companies	22
 APPENDICES	
A. United States Government Depreciation Cost Principles and Procedures.	24
B. West German Government Depreciation Cost Principles and Procedures.	26



CAPITAL QUOTES . . .

in the aerospace industry

The aerospace industry, and possibly other sectors of the U.S. economy cannot continue into the 1980s without changes in replacement cost accounting and tax procedures, if inflation persists at levels experienced in recent years.

For every dollar of new capital formed in the aerospace industry, one dollar showed up as an understatement of depreciation costs and overpayment of taxes on real profits.

While the capital base of the U.S. aerospace industry is being eroded, the German base is being maintained and supported through accounting practices that ensure a stricter observance of market principles in accounting standards, tax laws and public contract procedures.

the private sector

A significant barrier to achieve the required investments in private industry today are artificial accounting distortions that penalize long-term efficient investments.

Federal Government Regulations . . .

Clearly, under current U.S. accounting rules, inflation introduces a strong disincentive to any investment of funds in equipment, machinery or other depreciable assets.

The current U.S. practice of nominal depreciation is inequitable and causes extensive distortion in the accounting process. Real depreciation, based on reacquisition costs, is a method more firmly founded on economic considerations to insure a correct reflection of market principles and prices.

and, for the U.S. economy

When inflation persists over several successive years at rates above 5 percent, the U.S. economic system may become seriously affected by accounting distortion to the point of potential, persistent stagnation, which comes about when gross investments minus real depreciation costs equal zero.

If inflation persists, the difference between nominal and real depreciation will have far-reaching effects on capital formation, the incidence of corporate income taxes, government procurement, the performance and liquidity of corporations and, hence, on the long-term outlook for the U.S. economy.





INTRODUCTION

One of the most pressing problems besetting American industry today is the matter of "capital formation," the process of raising cash to maintain and expand the productive capacity of the United States economy—its machinery, tooling, plant and transport equipment.

The problem is simply that there is not enough investment money available to meet industry's needs. When such a situation exists, industry is unable to modernize plant facilities and replace worn out machinery. This in turn induces rising production costs, declining productivity and loss of jobs. The end result is stagnation of the production effort with attendant detriment to the general economy and the national standard of living.

Significant barriers to achieving the required investments in private industry today are artificial accounting distortions that penalize long-term efficient investments.

The situation has already reached acute dimensions. Uncorrected, it threatens a lasting capital crisis that will have a severe impact on the U.S. economy. The urgency of the matter is underlined by the fact that many economists and industrialists feel the capital formation problem is more serious than the energy shortage.

The need for investment capital—to promote productivity growth and enhance job opportunities, to combat inflation and protect U.S. competitiveness in the international market—is staggering. Leading financial spokesmen have estimated that the U.S. private sector will require \$4 to \$5 trillion over the next ten years to support a strong national economy. About half of these funds are needed simply to replace and maintain the capital already invested. The question is where to get the funds.

Traditionally, there are four methods by which industry raises essential investment capital:

- Depreciation charges, or annual allowances for depreciation of plant and equipment; theoretically, this should provide the funds for replacement of equipment when the original equipment reaches the end of its useful life;
- Re-invested profits, a portion of earnings put back into the business enterprise;
- Debt structure, or borrowings from lending institutions;
- New equity, or issuance of additional stock shares.

In the current economic environment, it is extremely difficult to raise investment capital by any one of these methods. It is beyond the scope of this report to detail the obstacles to capital formation through the latter three approaches—profit re-investment, debt and new equity: these approaches traditionally financed the growth in capital.

Instead, the study focuses on depreciation and the erosive effect of inflation on depreciation charges; on what is needed simply to maintain and replace the capital already invested. It finds that depreciation allowances, based on the original purchase costs of equipment, do not generate sufficient funds to replace plant and equipment when its useful life has ended, because the same or comparable equipment will cost a great deal more in periods of high inflation.

Concentrating on the aerospace industry, the study examines the extent of this discrepancy—the difference between nominal depreciation based on original costs and real depreciation based on inflated replacement costs. The study concludes that depreciation costs in the aerospace industry were understated by \$1.1 billion for the decade 1965 through 1974, and corporate income taxes overstated by \$540 million. Even at reasonable levels of inflation over the next ten years, the effect of this discrepancy on capital formation in the aerospace industry will be very severe, to the extent of anywhere between \$4.8 billion and \$8.5 billion.

The study also observes that major industrial countries competing with the U.S. already recognize real depreciation costs (e.g., West Germany and Japan) or are moving officially toward such recognition (e.g., Great Britain).

SUMMARY

The strength of the United States economy lies in its skilled labor force, its technology and its capital stock.¹ While all three of these factors are equally important elements in any economic society, contemporary problems have underscored the major role of capital expansion in supporting both a skilled labor force and technological advancement. Indeed, heavy financial investments are necessary to expand the labor force and to replace obsolete equipment and thereby assure the productive base for future U.S. economic growth.

In principle, *expansion* of an industry's capital stock is financed by re-investment of profits, by additional debt or by additional equity. *Replacement* of capital stock should properly be financed by funds recovered through depreciation allowances, which spread the cost of a physical asset over the number of years it will be in use. This would be possible if a new item of capital stock cost the same as the original depreciated item it replaces. Such, obviously, is not the case in times of persistent inflation; replacement stock invariably costs more and the accumulated depreciation, based on the original cost of predecessor stock is inadequate to cover the higher costs.

Thus it is essential that an inflation factor be incorporated in depreciation accounting procedures. Most studies of inflation recognize the obvious short-term impacts of rising production costs, but they neglect the cumulative longer term impacts and they fail to show how to account correctly for the financial requirements essential

to maintenance or expansion of an industry's capital stock. This study details the extent of the discrepancy that exists because current accounting procedures, imposed by tax laws and procurement regulations, overlook the inflation factor in the depreciation process.

Existing accounting procedures are designed to prevent arbitrary overstatements which would distort the financial profile of a corporation or an industry. For example, depreciation *in excess* of the costs necessary to replace capital stock would result in hidden profits, since depreciation is a cost of production and costs would be overstated in the accounting process. The hidden profits would not show up as earnings in the accounting process, hence corporate taxes would be underpaid. Similarly, procurement costs to the Federal Government would be overstated. Applying the hidden profits, a corporation would be able to finance capital stock *expansion* without resorting to debt or additional equity. However, such an accounting procedure is inequitable and inefficient as it leads to wasteful overinvestment. Accordingly, such procedures are not allowed under government regulations.

Conversely, opposite results obtain when depreciation is *below* the costs of replacing capital stock. In this instance, production costs are understated and profits are overstated. Taxes are overpaid and government procurement costs show up in the accounts lower than actual. Depreciation allowances are not adequate to cover replacement of capital stock, so a firm may have to resort to debt or additional equity just to maintain its capital stock. Because of the deleterious influence on capital formation, the distortions inherent in underdepreciation constitute a severe hindrance to continued economic growth. Clearly, accounting procedures that involve understatement of depreciation costs are also inefficient and inequitable; yet that is exactly the situation that exists today because the inflation factor is not recognized in the accounting process.

While industry, government and research organizations are presently seeking to revise certain accounting requirements, the fact remains, under current U.S. tax laws and procurement regulations, depreciation accounting practices are most often based on historical purchase prices, or the

¹Capital stock: the inventory of physical plant and equipment, such as buildings, machinery, tools, transport and distribution systems and other similar factors of production necessary to generate product output (income), as distinguished from labor, materials and money capital, i.e., cash, bank accounts, lines of credit and other sources of liquidity.

original cost of the equipment, rather than the current acquisition cost—what it would take to replace the same capital stock in an inflated marketplace.² In periods of inflation, these *real depreciation costs* are substantially higher than the historical costs, henceforth termed *nominal depreciation costs*. The higher the rate of inflation, the larger the discrepancy, magnifying the inequities and inefficiencies of understated depreciation. Sectors of the U.S. economy that are capital intensive³ are hurt proportionately more than non-capital intensive sectors.

This inflation-induced discrepancy in depreciation costs, and its attendant eroding effect on capital formation in the U.S. economy, is the subject of this study. Focusing on the aerospace industry, the study measures the capital-eroding effect of inflation and seeks to determine its implications for the future of the private free enterprise system in the U.S.

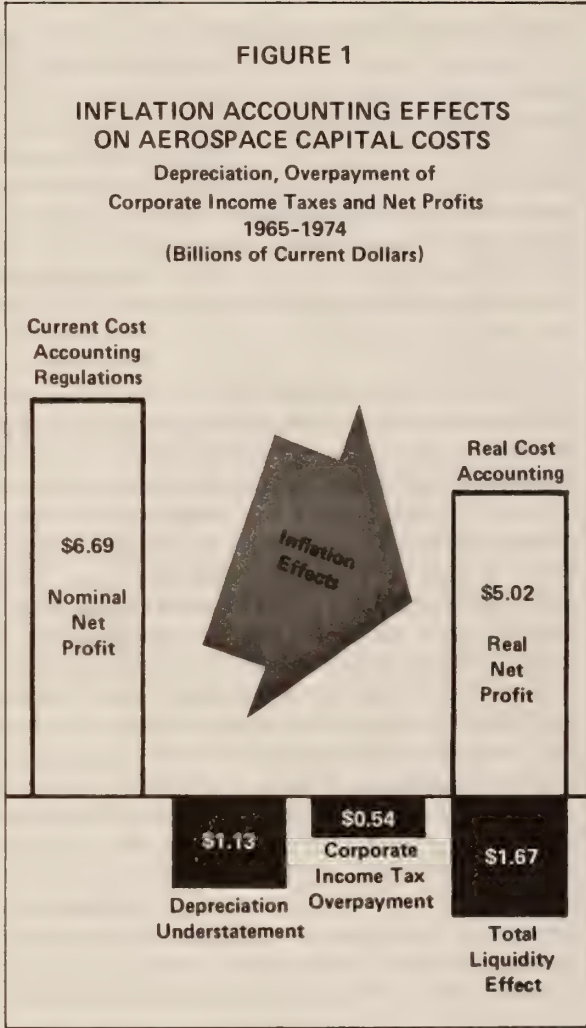
The study analyzed the performance of 50 U.S. corporations, most of which are engaged in aerospace endeavor, though with varying product lines and varying degrees of aerospace output; some are primarily aerospace companies, others diversified corporations with aerospace interests, still others producing aerospace-associated products such as electronics and communications equipment. In addition, the study analyzed data for the aerospace industry⁴ as a whole. These analyses provide

- An empirical investigation of the effects of inflation on capital formation in the aero-

space industry for the decade 1965 through 1974, and,

- An assessment of the effects of continued inflation on the aerospace industry between 1975 and 1984, applying inflation rates ranging between 5 and 10 percent annually.

In the ten-year span 1965–1974, real depreciation costs of the U.S. aerospace industry were higher by a total of \$1.1 billion than the nominal depreciation costs stated in industry accounts (See Figure 1); nominal depreciation costs were \$5.7 billion, real depreciation costs \$6.8 billion. This discrepancy caused an overstatement of corporate income taxes by \$543 million (out of a



²While opportunities for accelerated depreciation investment tax credits do exist under current law, their purpose is both limited and arbitrary and therefore not readily applicable to many tax situations, especially in high-technology industries.

³Corporations that need a large amount of equipment, machinery, tooling and other physical assets to produce their goods or services. The capital intensity of a corporation can be measured either by its percentage of durable assets to total corporate assets, or by depreciation costs as a percentage of total costs of production or gross profit. By either of these measurements, the aerospace industry is relatively capital intensive.

⁴Data as taken from the Federal Trade Commission "Quarterly Financial Report for All Manufacturing Corporations." Through 1970 the data base represents companies classified in Aircraft and Parts; beginning in 1971 the data base was expanded to include companies also engaged in guided missiles, spacecraft and related components and parts businesses.

total tax bill of \$4.6 billion) and a liquidity outflow of about \$1.7 billion.

In Figure 2, the impact of this distortion over the ten-year span 1975–1984 is projected, applying inflation rates of 5, 7.5 and 10 percent. Using the median 7.5 percent inflation rate, the projection shows that depreciation will be understated by \$4.4 billion, assuming continuance of current accounting and tax regulations. Taxes will be overpaid by \$2.1 billion and total liquidity outflow will amount to approximately \$6.5 billion; this amount is equivalent to the total net profits of the aerospace industry from 1965 to 1974.

Equally disturbing are the findings for the 50 U.S. corporations included in the study sample. The discrepancy, or the adjustment from nominal to real depreciation costs, amounts to \$9.6 billion in the 1965–1974 time period. Projecting through 1975–1984, and again assuming the 7.5 percent

annual inflation rate, the adjustment amounts to \$32.2 billion; this is more than 50 percent of the total net profits of these companies over the past ten years. The corporate income tax overpayment for the same period comes to about \$15.5 billion.

The study concludes that, if inflation persists, the difference between nominal and real depreciation will have far-reaching effects on capital formation, the incidence of corporate income taxes, government procurement, the performance and liquidity of corporations and, hence, on the long-term outlook for the U.S. economy.

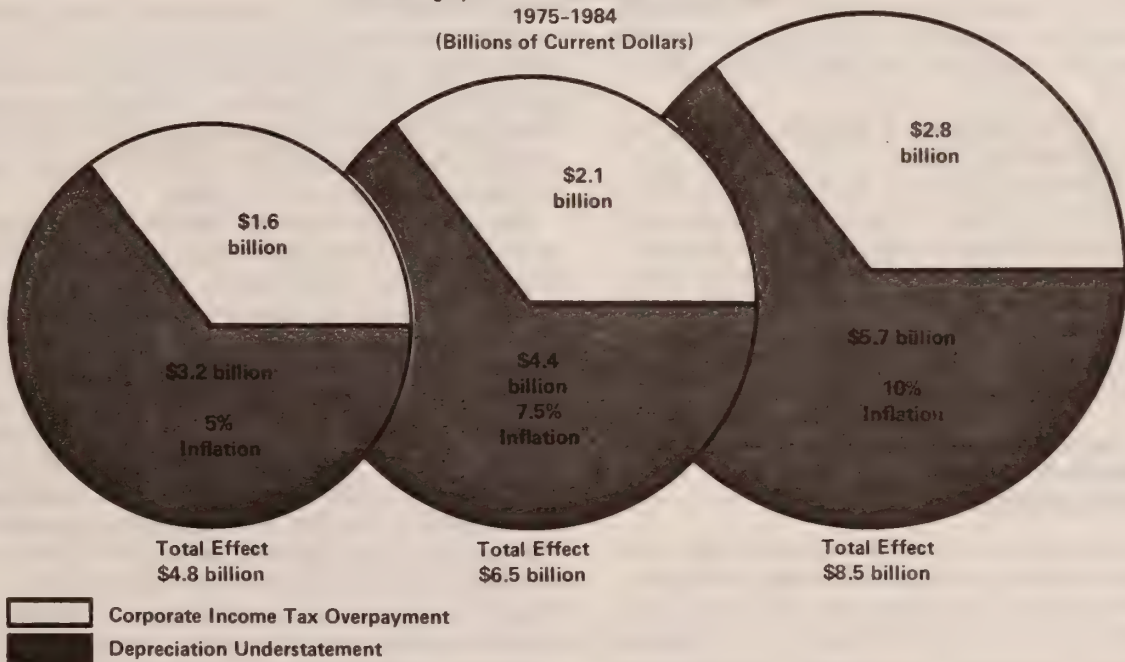
This report includes presentations concerning:

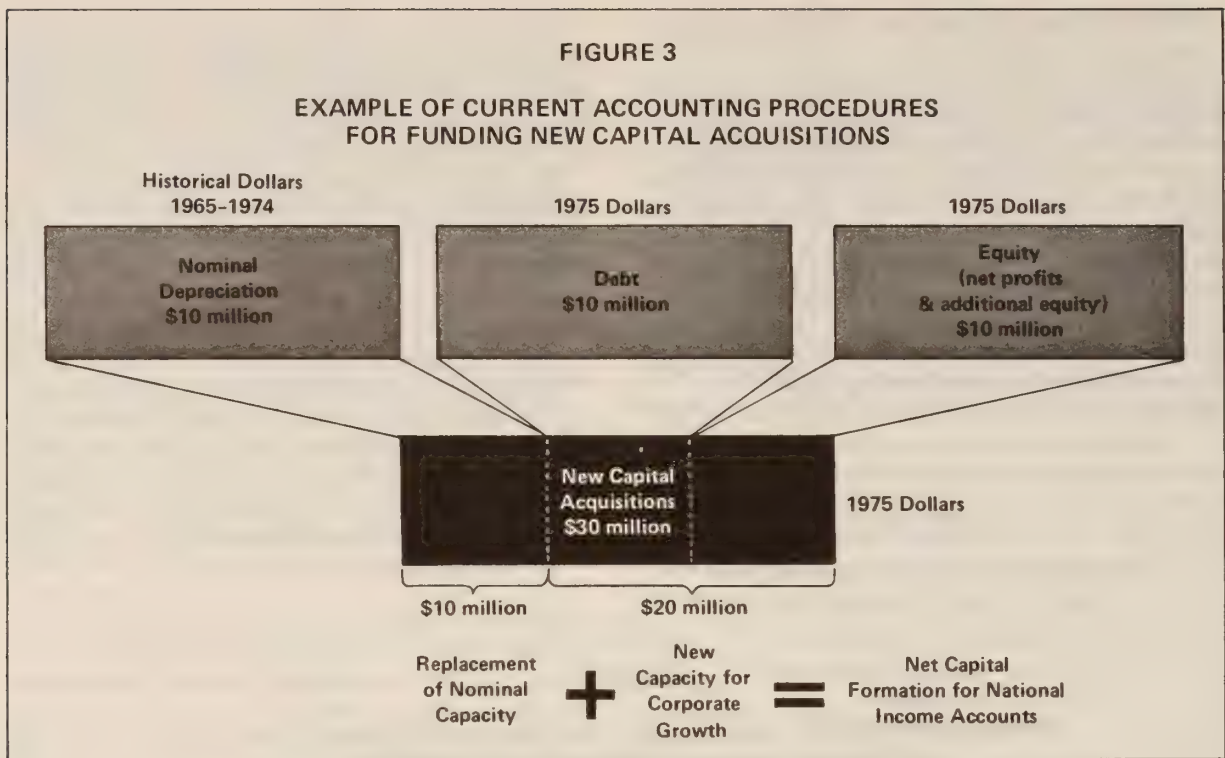
- the difference between nominal and real depreciation and its effect on capital formation,
- the results for the U.S. aerospace industry based in part on data covering the total aerospace industry as well as on an analysis of the sample U.S. corporations,

FIGURE 2

ESTIMATED ACCOUNTING EFFECTS ON AEROSPACE CAPITAL COST,
DEPRECIATION AND CORPORATE INCOME TAX

Current Accounting Costs
Assuming 5, 7.5 & 10 Percent Inflation Rates
1975–1984
(Billions of Current Dollars)





- the more general implications of accounting distortions with regard to the present state of the U.S. economy and the future outlook, and,
- recommendations for government and industry actions.

The report also includes, in Appendices A and B, a summary of procurement regulations governing allowability of depreciation cost as of October 1975, contrasted to the regulations, effective since November 1953 of the Federal Republic of Germany, the first to introduce cost accounting principles based on reacquisition costs of equipment rather than historical costs.

1. DEPRECIATION, CAPITAL FORMATION AND INFLATION: NOMINAL VS. REAL DEPRECIATION

Depreciation is an artificial accounting tool whereby the costs of physical assets acquired in one accounting period are spread over subsequent accounting periods equal to the useful lifetime of the assets. For example, a firm spends

\$30 million in 1975 for new machinery that will be in use for ten years. The money is spent in 1975, but the machinery is not used up in the process of generating 1975 production. Depreciation allocates the \$30 million investment against the production revenues that will be obtained over the ten years the machinery is used.

Depreciation thus allows the recovery of funds to make up for the initial investment of resources. Depreciation is a valid "cost" in measuring corporate performance in a current year, whether or not the recovered funds are actually used to replace the asset at the end of its useful life. Asset values not yet depreciated are carried forward to future years. The concept of depreciation is recognized in U.S. tax law and procurement regulations, which define depreciation broadly as a "reasonable deduction" for the wear-and-tear on capital stock in a given accounting period. Funds recovered by such deductions should assure the corporation of the opportunity to make a similar investment at the end of the useful life of the asset.

Figure 3 describes the current accounting pro-

cedures involved in the acquisition of additional capital stock. In this example, a firm acquires \$30 million worth of new machinery. Of the total, \$10 million is funded through depreciation. The remaining \$20 million is funded half by debt (\$10 million) and half by issuing new shares to raise equity (\$10 million). Had there been no inflation over the past ten years, \$10 million worth of the

newly acquired machinery would replace equivalent machinery bought ten years ago at a cost of \$10 million. The other \$20 million would be correctly measured as *added* capital stock, providing new capacity for corporate growth. This is the way U.S. accounting rules determine depreciation and new capital formation—without regard to inflation. Obviously, these accounting rules

TABLE 1
FINANCIAL HISTORY OF A CAPITAL ASSET
Ten Year Uselife
(Millions of Dollars)

ASSUMPTIONS: Acquisition price \$10 Expected uselife 10 years Rate of inflation 10 percent annually Corporate income tax 48 percent 25 percent of profits before taxes retained; balance distributed							
A	B	C	D	E	F	G	H
Year	Depreciation 10% Annually	Reacquisition Cost Calculation		Overstated Profit D-B	Corporate Income Tax 48% on E	Distributed Overstated Profit 27% on E	Retained Overstated Profit 25% on E
		Asset Price 10% Inflation	Depreciation 10% on C				
1	\$ 1.0	\$ 11.0	\$ 1.1	\$ 0.1	\$.048	\$.027	\$.025
2	1.0	12.1	1.2	0.2	.096	.054	.050
3	1.0	13.3	1.3	0.3	.144	.081	.075
4	1.0	14.6	1.5	0.5	.240	.135	.125
5	1.0	16.1	1.6	0.6	.288	.162	.150
6	1.0	17.7	1.8	0.8	.384	.216	.200
7	1.0	19.5	2.0	1.0	.480	.270	.250
8	1.0	21.4	2.1	1.1	.528	.297	.275
9	1.0	23.6	2.4	1.4	.672	.373	.350
10	1.0	25.9	2.6	1.6	.763	.432	.400
Σ	\$10.0	\$ na	\$ na	\$ 7.6	\$3.600	\$2.100	\$1.900
TEN YEAR SUMMARY: Reacquisition price \$25.9 Total overstated profit \$7.6 Tax paid on overstated profit \$3.6 Distributed overstated profit \$2.1 Total cash outflow due to overstated profits \$5.7							

na Not applicable.

and regulations were formulated during a period of monetary stability.

When one looks at the same transaction and assumes a 10 percent annual rate of inflation, a completely different picture emerges. Table 1 illustrates the effect; it shows the following:

Column A: The ten years of the asset history.

Column B: The annual nominal depreciation under existing U.S. accounting procedures. In this case the straight line depreciation method is employed and depreciation is listed at \$1 million a year, or one-tenth of the original value of the \$10 million worth of machinery acquired ten years ago.

Column C: The reacquisition cost of the asset at the end of each year, assuming a 10 percent rate of inflation. After ten years it would cost \$25.9 million to replace the original \$10 million worth of machinery.

Column D: Depreciation computed on the basis of the reacquisition cost in Column C rather than on the original cost. (Other methods suggest that the price the corporation might realize for the machinery on the market could be used as a depreciation base.)

Column E: The overstatement of profits resulting from the use of nominal rather than real depreciation costs. *Over the ten year period, the corporation will report a total of \$7.6 million in profits which are not really profits; they are in fact part of the cost of capital, that is, depreciation.*

Column F: The corporate income taxes on that portion of the profit that has been overstated due to the use of nominal depreciation charges. Over the ten years the corporation will pay \$3.6 million in taxes on profits which in fact do not exist.

Column G: The dividend distributions that the corporation will make, based on overstated profits. The 27 percent figure roughly represents available

dividend after taxes and retained profits.

Column H: The retained portion of the overstated profit, amounting to a total of \$1.9 million over the ten year span.

Had there been no inflation during the period covered in the table, each of the columns D through H would "zero out." The fact that positive entries are shown is due to the illusory effect of inflation when capital assets are evaluated in terms of original costs.

In summary, the table shows:

- An overstated profit of \$7.6 million,
- Payment of \$3.6 million in corporate income tax on the overstated profit,
- Distribution of \$2.1 million in dividends, and
- "Equity" amounting to \$1.9 million in retained profits.

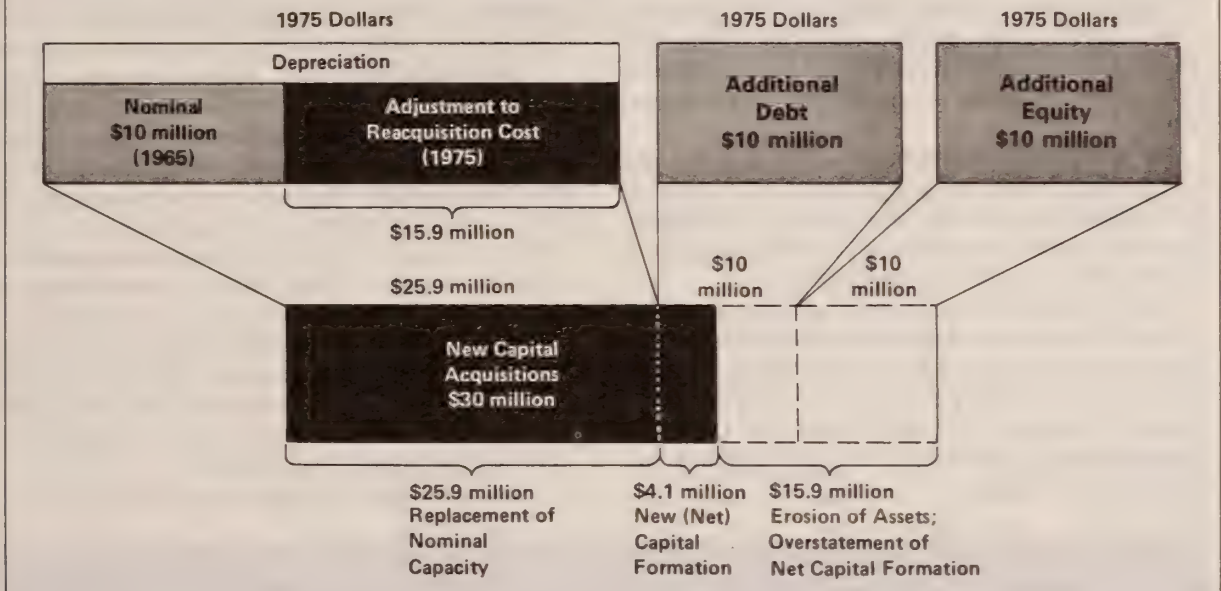
Figure 4 shows the new picture of the transaction that emerges when *real* cost accounting, which considers the 10 percent inflation factor, is employed. To maintain its productive base by replacing the original \$10 million worth of machinery, the corporation now has to lay out \$25.9 million. Thus, in investing the earlier-mentioned \$30 million, the corporation incurs \$10 million in new debt and has to issue new shares for \$10 million, but \$25.9 million of the \$30 million goes to replace the original \$10 million worth of 1965 vintage machinery. Only \$4.1 million is *net added investment*. The new financing needed in addition to available depreciation funds to replace the 1965 machinery—\$15.9 million—represents an erosion of corporate assets. Clearly, under current U.S. accounting rules, inflation introduces a strong disincentive to *any* investment of funds in equipment, machinery or other depreciable assets. Additionally, where the prices of products are also determined by "historical" costs, or by government-regulated pricing procedures (exemplified by public utilities, Department of Defense, the National Aeronautics and Space Administration, and the Energy Research and Development Administration), investments for maintaining the capital base for the production of these products cannot be continued for long.

The current U.S. practice of historical depreciation is inequitable and causes extensive distortion

FIGURE 4

EXAMPLE OF REAL COST ACCOUNTING PROCEDURES FOR FUNDING NEW CAPITAL ACQUISITIONS

Assuming 10 Percent Inflation
and 10 Year Useful Life



in the accounting process. Real depreciation, based on reacquisition costs, is a method more firmly founded on economic considerations to insure a correct reflection of market principles and prices.

2. AEROSPACE INDUSTRY RESULTS

The study's examination of the 50 selected corporations, on a yearly basis for the decade 1965 through 1974, used 20 or more years of corporate data and historical price indices. From evaluation of this data, the study calculated a set of principal series to measure the effects of depreciation cost adjustments:

- The asset acquisition history of each corporation for each year, making up the total gross assets in current year dollars.
- The age structure of the assets, including the economic asset life used.
- The corporate asset price indices for each corporation, which permit adjustment of his-

torical acquisition costs to current year reacquisition costs.

- The depreciation adjustment, the difference between real and historical depreciation.
- The incidence of depreciation on corporate taxes, profits and liquidity if *real* depreciation costs were used.
- The effect of depreciation on net corporate capital formation. Net capital formation is defined as total new capital acquisitions minus real depreciation costs.
- The incidence of the investment tax credit and its partial offsetting of the inflation effect. (While investment tax credit data are available for most of the 50 corporations, data for the aerospace industry do not include an investment tax credit series.)

The aggregate results of this evaluation of the U.S. aerospace industry are shown in Table 2. This table lists, for the years 1965–1974, the historical performance of the aerospace industry under existing accounting rules (nominal values) and under adjusted accounting rules (real values).

The individual series and their calculations are described in detail in the main body of the report. The results measure the *effect* of inflation on corporate accounts and performance but provide no clue as to how to *solve* the problem of inflation. The results do show, however, that an adjustment of depreciation to reacquisition cost accounting could have a major effect in alleviating the present severe erosion of liquidity and capital formation *whatever* other economic policies are pursued.

As of 1974 and based on nominal costs, the gross value of property, plant and equipment in the aerospace industry was about \$10.4 billion. Valued in terms of reacquisition costs, these same assets amount to about \$14.2 billion.

The principal process determining the magnitude of the adjustment in asset and depreciation values shown in Table 2 is embedded in the capital acquisition history of each corporation and the levels of inflation. The age structure of the aerospace industry, based on these investment series, is shown in Figure 5.

After the initial build-up of aerospace capital in the 1960s, a dramatic drop in new acquisitions occurred between 1969 and 1973. This was reversed only partially in 1974, to levels experienced in the mid-1960s (about \$1 billion). In *constant* dollars the drop in new acquisitions over the latter five years is even more substantial than the current year acquisition numbers would indicate.

These data show that, in terms of new investments and capital formation growth, the U.S. aerospace industry suffered a marked decline in the 1970s. A particularly disturbing note is the fact that the asset life for the aerospace industry (Table 2) has consistently increased over the 1965-1974 time span, from a ten year maximum life in 1965 to 15 years in the 1970s. This indicates an "aging process," caused in large measure by the industry's inability to obtain additional capital for updating obsolete equipment. Inefficiencies and a retarded productivity rate of growth are inevitable results when an industry cannot avail itself of the most advanced technology.

Over the same ten years, the aerospace indus-

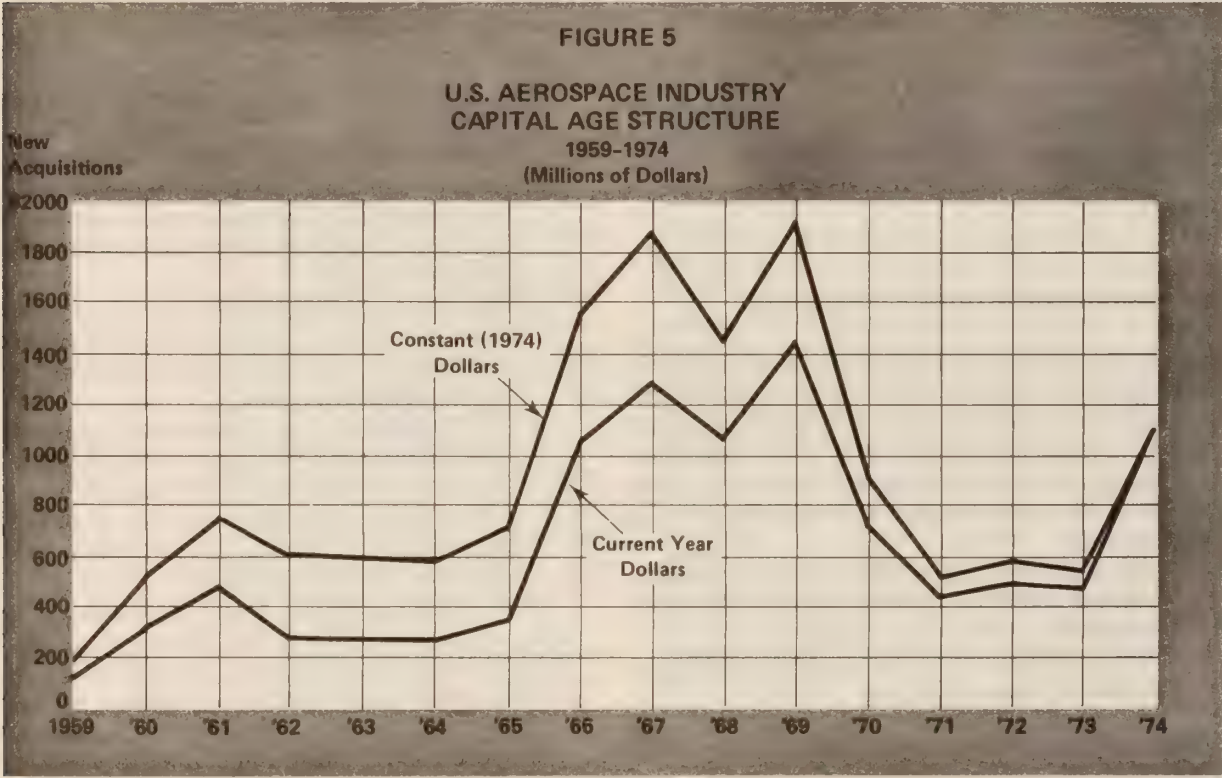


TABLE 2

ANALYSIS OF NOMINAL VERSUS REAL CAPITAL FORMATION

Aerospace Industry

1965-1974

(Millions of Dollars)

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	TOTAL
ASSETS											
Gross Property, Plant and Equipment											
Nominal Value	\$ 3,956	\$ 4,946	\$ 6,459	\$ 7,431	\$ 8,815	\$ 9,350	\$ 9,474	\$ 9,991	\$ 9,586	\$10,403	
Real Value	4,272	5,368	7,122	8,355	10,116	11,125	11,598	11,915	12,311	14,216	
Corporate Asset Indices											
Price Index	1.08	1.09	1.10	1.12	1.15	1.19	1.22	1.24	1.28	1.37	
Asset Life	10.41	11.31	12.92	13.74	14.61	15.11	15.30	15.30	15.00	15.29	
INCOME STATEMENT											
Nominal Gross Profit	\$ 984	\$ 1,045	\$ 1,099	\$ 1,606	\$ 1,433	\$ 881	\$ 761	\$ 1,103	\$ 1,443	\$ 1,451	\$11,811
Depreciation											
Nominal Cost	300	349	465	587	668	688	655	677	653	631	5,673
Real Cost	324	379	513	660	767	819	802	841	839	862	6,804
Difference	-24	-30	-48	-73	-99	-131	-147	-164	-186	-231	-1,131
Income Tax											
Nominal	460	473	489	749	629	380	338	494	593	-	4,605
Real Change	-12	-14	-23	-35	-47	-63	-70	-79	-89	-111	-543
Nominal Net Profit	524	572	610	857	804	501	423	609	855	938	6,693
Liquidity Impact											
Real Change	-35	-44	-71	-108	-146	-193	-217	-243	-275	-342	-1,674
CAPITAL FORMATION											
Current Year Acquisitions	\$ 464	\$ 1,029	\$ 1,284	\$ 1,040	\$ 1,433	\$ 719	\$ 424	\$ 489	\$ 478	\$ 1,081	\$
Net Capital Formation											
Nominal	164	580	819	453	765	31	-231	-188	-175	450	2,768
Real	140	650	771	380	666	-100	-378	-352	-361	219	1,637
Difference	-24	-30	-48	-73	-99	-131	-147	-164	-186	-231	-1,131

try generated about \$6.7 billion in net profits, calculated under current accounting rules. Nominal depreciation costs for the decade were \$5.7 billion, but real depreciation was \$6.8 billion; thus the discrepancy, or depreciation difference for the aerospace industry, was on the order of \$1.1 billion.

The study also points up the rapid acceleration in depreciation adjustments since 1969, from a level of about \$100 million a year to more than \$231 million by 1974. This in turn has a serious effect on real capital formation. In Figure 6, the difference between nominal and real net capital formation is shown for the years 1965-1974.

TABLE 3
ANALYSIS OF PROJECTED VERSUS REAL CAPITAL FORMATION
Aerospace Industry
1975-1984
7.5 Percent Inflation
(Millions of Dollars)

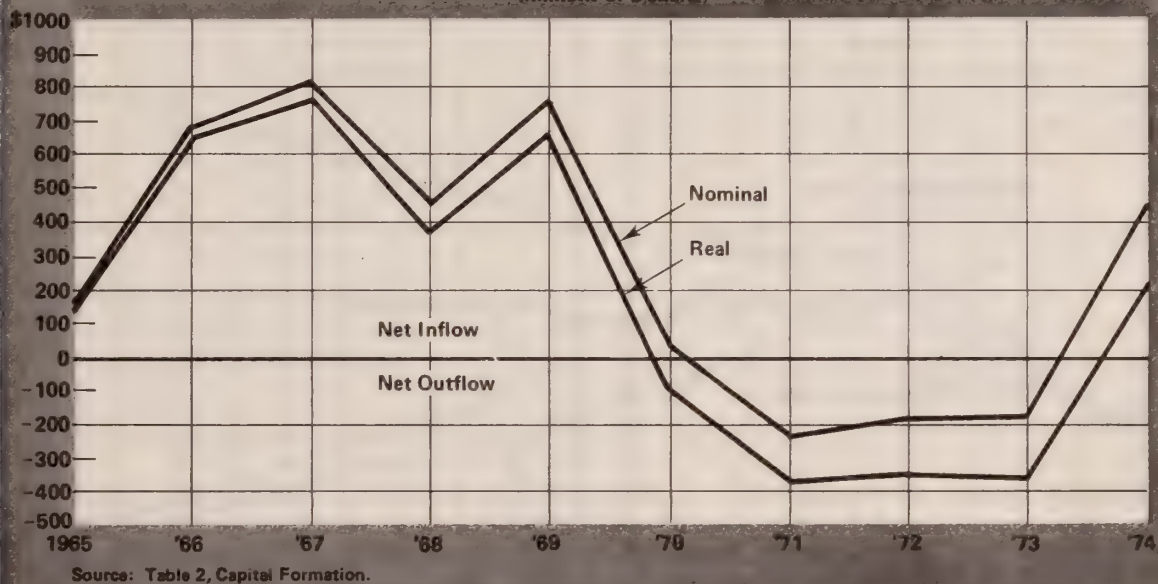
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	TOTAL
ASSETS											
Gross Property, Plant and Equipment											
Projected Value	\$10,602	\$10,802	\$11,001	\$11,201	\$11,400	\$11,600	\$11,799	\$11,998	\$12,198	\$12,397	
Real Value	15,077	15,491	16,802	17,656	18,529	19,369	20,190	20,963	21,696	22,373	
Corporate Asset Indices											
Price Index	1.42	1.48	1.53	1.58	1.63	1.67	1.71	1.75	1.78	1.80	
Asset Life	14.91	14.68	14.10	13.60	13.72	14.16	14.68	15.21	15.21	16.09	
INCOME STATEMENT											
Depreciation											
Projected Nominal Cost	\$ 641	\$ 652	\$ 662	\$ 673	\$ 683	\$ 694	\$ 704	\$ 714	\$ 725	\$ 735	\$ 688
Real Cost	912	962	1,011	1,061	1,110	1,158	1,205	1,248	1,289	1,327	11,284
Difference	-271	-310	-349	-388	-427	-464	-501	-534	-564	-592	-4,401
Income Tax Overpayment	-130	-149	-168	-186	-205	-223	-240	-256	-271	-284	-2,112
Liquidity Impact	-401	-459	-517	-575	-632	-688	-741	-790	-835	-876	-6,513
CAPITAL FORMATION											
Current Year Acquisitions	\$ 721	\$ 732	\$ 742	\$ 752	\$ 762	\$ 773	\$ 784	\$ 794	\$ 805	\$ 815	\$
Net Capital Formation											
Projected Nominal	80	80	80	80	80	80	80	80	80	80	797
Real	-19	-230	-270	-309	-348	-385	-421	-454	-485	-512	-3,604
Difference	-27	-310	-350	-389	-428	-465	-501	-534	-565	-592	-4,401

Excluding 1974, the aerospace industry paid about \$4.6 billion in income taxes during the decade. The tax liability would have been lowered by about \$543 million, or 12 percent of the total, if real depreciation costs had been allowed. By 1974, the overpayment of corporate income taxes was substantially larger than in earlier years: about \$111 million for all of the aerospace industry. This taxation of nominal—but not real—profits erodes the capability of the industry for replenishing its capital stock and also inhibits venturing new investments and ideas.

The combined outflow of funds amounts to more than \$1.7 billion. This is a figure equal to 60 percent of the industry's *nominal* net capital formation (\$2.8 billion) over the past ten years, or 100 percent of the *real* capital formation during that period. *For every dollar of new capital formed in the aerospace industry, one dollar showed up as an understatement of depreciation costs and overpayment of taxes on real profits.*

The overstatement of real capital formation in the aerospace industry in the 1965-1974 period amounts to more than \$1 billion. This is equiva-

FIGURE 6
 U.S. AEROSPACE INDUSTRY
 NOMINAL VS. REAL NET CAPITAL FORMATION
 1965-1974
 (Millions of Dollars)



lent to 40 percent of what is shown on government and corporate books as net capital formation. The billion-plus may also be compared to the *nominal* net profits of \$6.7 billion for the industry.

Although the erosion effect of accounting distortion has been substantial, the aerospace industry so far has been able to absorb it. Considering the magnitude of the distortion, however, it is a matter of conjecture whether the present system of free enterprise can continue to cope with existing accounting rules over the next generation, or even over the next decade. What is the "adjustment effect" likely to be when projected over the next ten years? Can the aerospace industry manage to adjust to it?

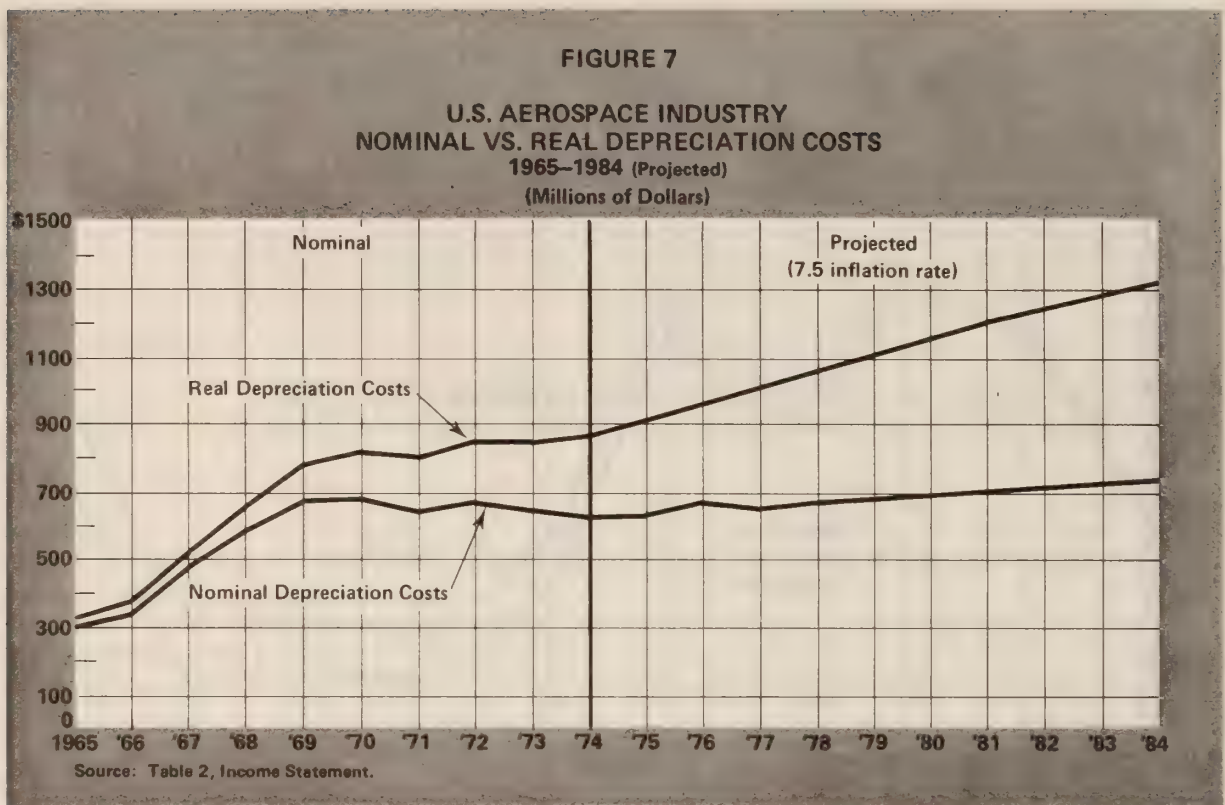
To gain a better understanding of the likely impacts, the study made projections for the 1975-1984 period of capital formation, depreciation adjustments and tax impacts. Three different potential levels of inflation were employed: 5 percent, 7.5 percent and 10 percent. A projection was made for each of the 50 selected corporations,

then the results were aggregated to company groupings (primarily aerospace; diversified; electronic, communications and instrumentation; automobile and rubber; and all others). While none of the individual projections has any predictive value, the purpose is to illustrate that even under very conservative, or "steady state" conditions of corporate development, the impact of inflation on capital intensive corporations will be severe.

The results of the projections, and the impact of accounting distortion on the aerospace industry as a whole, are shown in Table 3, which is based on an annual inflation rate of 7.5 percent.⁵

The projections underline the fact that inflation rates ranging between 5 and 10 percent will produce a serious impact on aerospace industry capital formation. Even at the 5 percent level—and at relatively small increases in projected levels of

⁵Similar series were calculated for inflation rates of 5 percent and 10 percent; these results, along with the methodology are contained in Volume II of the report.



gross assets, plant and equipment—the depreciation adjustment alone would amount to \$3.2 billion over the ten year span (1975–1984). At 7.5 percent inflation, the adjustment would reach \$4.4 billion and at 10 percent it would come to \$5.7 billion. Figure 7 illustrates the widening gap between real and nominal depreciation costs over a 20 year period that includes the nominal (1965–1974) and the projected (1975–1984) annual magnitudes of the depreciation adjustment.

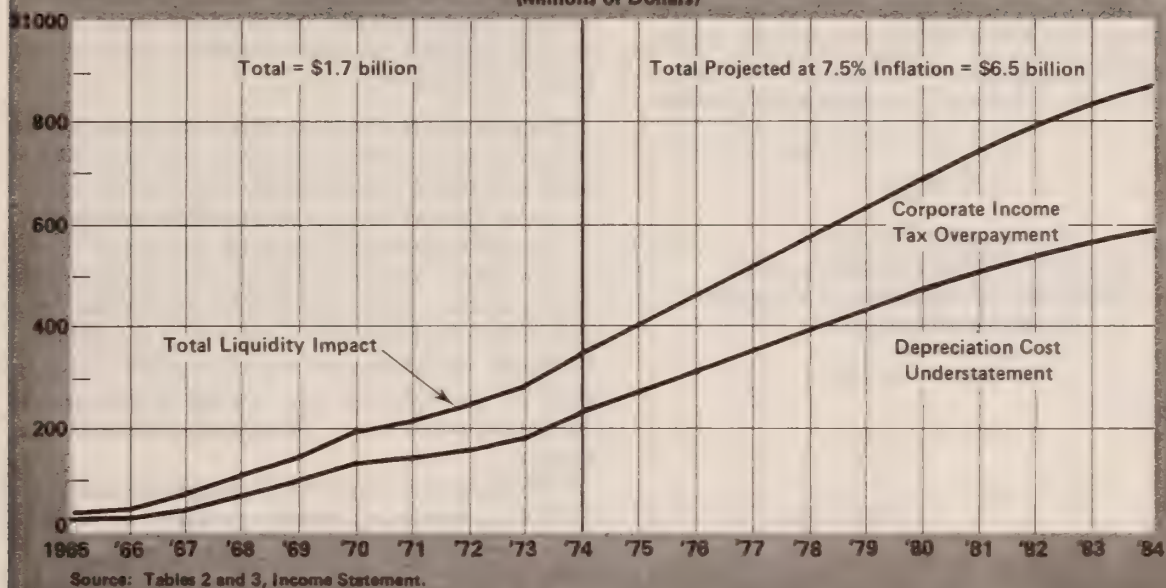
In addition to the depreciation adjustment, the projections also allow for the likely overpayment in corporate income taxes due to accounting distortion. Depreciation adjustment *combined with* tax overpayments provides a more accurate estimate of the total liquidity impact of inflation on financing new capital investments. Figure 8 shows the combined impact for the 20 year span, nominal and projected. The figure shows that total outflow of funds from the aerospace industry, solely due to accounting distortion, is expected to be \$6.5 billion.

At the 5 percent inflation rate, the total depreciation adjustment of \$3.2 billion is equivalent to about 50 percent of the total nominal net profits earned by the aerospace industry—\$6.7 billion—in the 1965–1974 period. At a 10 percent inflation rate, the depreciation adjustment equals about 67 percent of the industry's net profit. Even if net profits were to grow at 10 percent a year over the 1975–1984 decade, close to 40 percent of those earnings would be nominal profits due to understatement of real depreciation costs.

At the same 10 percent inflation rate, the projected overpayment in corporate income taxes—due to the difference between nominal and real depreciation—would amount to \$2.8 billion. Add that to the depreciation adjustment (\$5.7 billion) for a total liquidity outflow of \$8.5 billion.

The aerospace industry, and possibly other sectors of the U.S. economy cannot continue into the 1980s without changes in replacement cost accounting and tax procedures, if inflation per-

FIGURE 8
U.S. AEROSPACE INDUSTRY
LIQUIDITY IMPACT OF ACCOUNTING DISTORTION
1965-1984 (Projected)
(Millions of Dollars)



sists at levels experienced in recent years.

Since the total gross assets of the aerospace industry amount to only \$10.4 billion (1974 data), it is difficult to see how the industry can avoid serious liquidity and capital formation problems even in the absence of *further* significant inflation, which, realistically, probably means annual inflation rates of "only" 5 percent. This point becomes clear in a comparison of depreciation adjustments with nominal and projected net profits of the industry.

In Figure 9, the depreciation adjustment as a percent of net earnings (1975-1984 projection) is shown as a function of the rate of inflation. In this figure, the different groupings of companies are plotted separately and nominal profits are assumed. At 10 percent inflation, the depreciation adjustment alone would be almost equal to total projected net earnings of the aerospace industry. Even at the 5 percent inflation rate, the adjustment from nominal to real depreciation costs

amounts to a substantial part of the total net earnings of capital intensive industries, among them the aerospace industry.

Furthermore, while the spirit of the present corporate income tax law is to tax 48 percent of real profits, *in effect* the figure may go much higher. When applied to capital intensive industries the tax may vary from 48 percent of real earnings (at zero inflation rate) to 100 percent or more (at 10 percent inflation), as long as one continues to measure depreciation costs by ignoring inflationary price changes. This cannot be the intent of the corporate tax law, nor of government procurement cost provisions.

A final aspect of inflation effect on capital formation is shown in Figure 10, which covers the nominal/projected 20 year span 1965-1984. Two series are shown: the acquisition of new assets and the *real* depreciation costs; the difference constitutes outflow from the aerospace industry.

The figure shows a substantial build-up of capi-

tal stock from 1965 to 1969, followed by a substantial erosion of capital stock in 1970–1974, with 1974 a slight exception. The study projects a *nominal* net capital formation of about \$800 million during the 1975–1984 span. In fact, however, real depreciation costs more than offset the nominal figures. At 5 percent to 10 percent inflation, the real capital base of the aerospace industry would be eroded by anywhere between \$2.4 billion and \$4.9 billion (1974 dollars). Depending on the exact

level of inflation over the decade, the erosion of liquidity available to the aerospace industry will be even larger with an outflow of about \$6.5 billion (plus or minus \$1.7 billion).

Since the rate of inflation is clearly outside the control of the aerospace industry, the question of whether aerospace will survive as a viable sector of U.S. industry is beyond the control of the aerospace industry.

The preliminary analysis of the 50 corporations indicates that other sectors of industry—electronics and communications, auto and rubber, and diversified industries—are more or less in the same dilemma. Results for these other groupings are shown in Table 4 and Figure 9. The only sector not significantly affected by distortion—as one might expect—is the finance and retail sector. But the question arises: What is there to be financed and retailed if the capital intensive sectors of American industry are eroded?

The study concludes that U.S. government procedures, accounting standards and tax regulations have to be changed to reflect reacquisition costs of capital usage.

Existing U.S. government depreciation regulations in defense contracting (October 1975) are listed in Appendix A. Appendix B contains the economic depreciation practices, in effect since 1953, of the West German government. These appendices afford an interesting comparison, since the German rules recognize reacquisition cost accounting. While the capital base of the U.S. aerospace industry is being eroded, the German base is being maintained and supported through accounting practices that ensure a stricter observance of market principles in accounting standards, tax laws and public contract procedures.

The analyses of the 50 corporations show that past distortion of inflation on capital formation has been significant, but within industry's absorption capability. However, assuming reasonable levels of inflation over the next ten years, the cumulative distortion effect will be very severe for capital intensive corporations. Continued inflation and nominal accounting will lead to a strong disincentive, if not inability, of such corporations to finance investments and/or to generate additional capital.

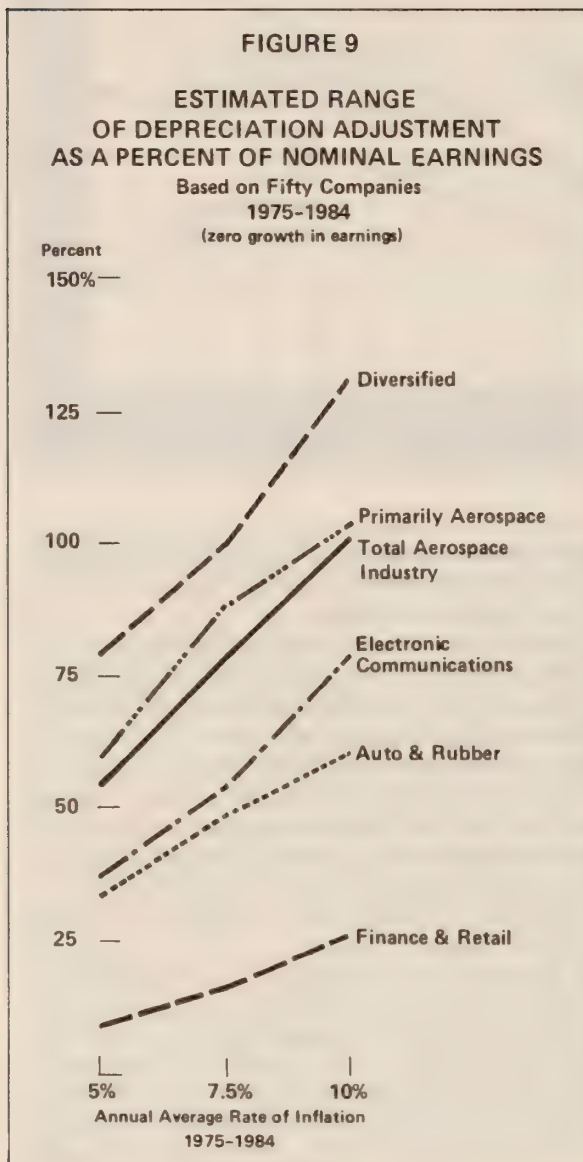


TABLE 4

SUMMARY: TEN YEAR NET PROFITS VERSUS DEPRECIATION ADJUSTMENT
1965-1974 and 1975-1984
 (Billions of Dollars)

Industry Sectors	TOTAL Net Profits 1965-1974	DEPRECIATION ADJUSTMENT			
		Nominal 1965-1974	Projected 1975-1984		
			5 Percent Inflation	7.5 Percent Inflation	10 Percent Inflation
Aerospace Industry	\$ 6.7	\$ 1.1	\$ 3.2	\$ 4.5	\$ 5.7
Aerospace Companies TOTAL	\$57.4	\$ 9.6	\$24.0	\$32.2	\$43.5
Primarily Aerospace	3.7	.9	2.2	3.0	3.8
Diversified	6.9	1.0	3.5	4.9	6.5
Electronics and Communications	20.0	3.0	7.9	11.3	15.0
Auto and Rubber	26.8	4.7	10.4	14.0	18.2
Other Finance and Retail	\$ 5.7	\$.3	\$ 1.0	\$ 1.4	\$ 1.9

3. ACCOUNTING DISTORTION AT THE NATIONAL LEVEL

While accounting distortion has a serious adverse impact on individual corporations and industries in periods of inflation, it may have a broader effect on the national economy as a whole and particularly on employment.

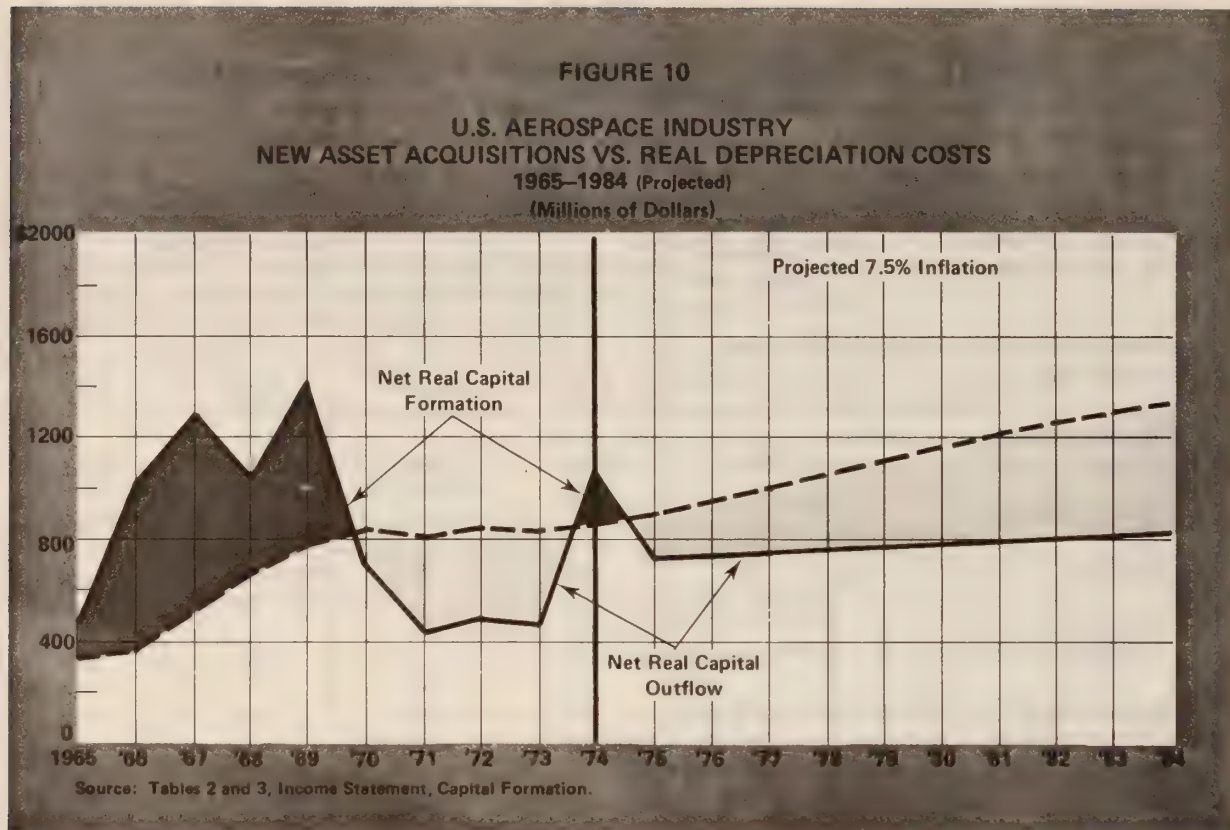
Modern economic theory holds that the rate of inflation can be reduced at the expense of increased unemployment and vice versa. Yet in the U.S. today there exist high rates of both unemployment and inflation, a condition known as "stagflation." Many economists seek answers in elaborate economic models. They would perhaps do better to reexamine some fundamentals—among them the effect of inflation on capital formation, hence employment.

As part of this study, the movements of major

U.S. economic indicators in the late 1960s and the 1970s were matched with the evaluation of U.S. corporate performance. The study concludes that *one contributing factor to stagflation—and its likely persistence—is current accounting procedure at the corporate and national levels in measuring, reporting and taxing economic performance of private enterprise.*

Investigation of this hypothesis was motivated by the observation that several European economies enjoyed full employment throughout the 1960s and 1970s with high rates of inflation. In these same economies, reformed accounting procedures that allow for the effects of inflation had been extensively implemented during the late 1940s and the 1950s; the same is true of Japan in the 1960s.

The same accounting distortion detailed previously at the corporation and industry level is ap-



parent on national income accounts. Figure 11 shows the magnitude of this distortion—the difference between nominal and real depreciation—at the national level for the period 1971–1974. The range of values for the depreciation adjustment is based on the study results for the 50 selected corporations.

As long as the rate of inflation remains at relatively low levels—such as those experienced in most of the postwar period up to the late 1960s—the use of nominal rather than real costs may not lead to serious misallocation of national resources. Real profits may be lower than reported, real corporate tax rates somewhat higher than 48 percent, and net investment somewhat lower as a percent of gross national product.

However, when inflation persists over several successive years at rates above 5 percent, the U.S. economic system may become seriously affected

by accounting distortion to the point of potential, persistent stagnation, which comes about when gross investments minus real depreciation costs equal zero.

Tentative calculations of the total national depreciation adjustment are listed in Table 5 which employs two sets of data:

- Department of Commerce—National Income Accounts data for nominal performance accounting in capital formation for the years 1971–1975;
- Study-developed rough-order-of-magnitude estimates of *real* capital formation over the same time period.

Examination of this data indicates that:

- *Real* capital formation in the U.S. has been about half what Department of Commerce publications indicate.
- Real net investment can be expected to re-

main close to zero if inflation persists.

- The adverse effects on capital formation, if not corrected, will persist over the useful life of current assets, even if inflation is controlled from now on.

- Accounting distortions may constitute an important explanation of the serious lack of net capital formation in the U.S., compared with economies in Western Europe and, even more so, with centrally-planned economies.

Accounting distortion effects and the attendant erosion of capital formation are a direct function of the rate of inflation. As long as existing U.S. accounting practices remain in effect, and the higher the rate of inflation, the earlier the stagnation point is reached, the greater the deficiency in capital formation, and the lower the future rates of economic growth and employment.

The results of this study indicate that costing practices as reflected in current U.S. accounting and tax regulations constitute an important contributing factor to creating a liquidity and capital formation crisis. A change in these rules would be a major step toward economic recovery.

4. RECOMMENDATION

The distortion effect inherent in existing U.S. accounting practices is a matter of grave concern for the economic health of capital intensive industries and the national economy in general. A necessary and immediate measure is a change in accounting regulations and tax laws. Specifically, the rules should be changed to incorporate recognition of this fact: that, in times of inflation, reacquisition costs of capital stock, rather than nominal costs, should be the basis upon which depreciation is calculated for:

- Corporate income taxation;
- Government procurement cost regulations;
- Corporate profit and dividend determination;
- Government economic indicator measurements, particularly of gross investment, net investment and capital formation for future growth.

While this measure will not solve the inflation problem, it will reflect the true cost of using capital in an inflationary economy. In the absence of such regulatory reform, distortions in capital formation and allocation will continue to undermine the capital base of the U.S. free market economy—and on an increasing scale.

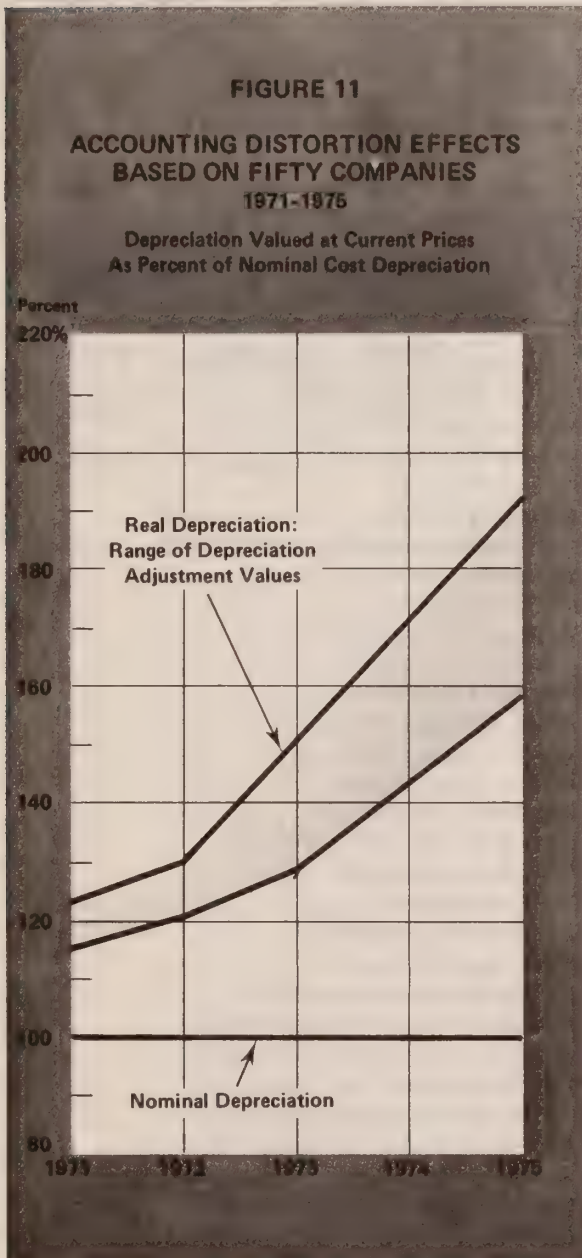


TABLE 5
THE IMPACT OF NOMINAL TO REAL DEPRECIATION
ON NET REAL INVESTMENTS
United States
1971-1974
(Billions of Dollars)

REAL ↓		1971	1972	1973	1974	1975 ^a
	Gross Investments ^c	\$153.7	\$179.3	\$209.4	\$209.0	\$173.0
	(-) Real Depreciation ^b	-114.3	-127.6	-141.8	-161.2	-183.0
	Net Real Investment ^c	39.4	51.7	67.6	46.8	-10.0
	Difference Real vs Nominal					
		-20.6	-24.7	-31.0	-43.8	-54.1
↑ NOMINAL	Net Nominal Investment ^c	\$ 60.0	\$ 76.4	\$ 98.6	\$ 90.6	\$ 44.1
	(-) Nominal Depreciation ^c	-93.7	-102.9	-110.8	-118.4	-128.9
	Gross Investments ^c	153.7	179.3	209.4	209.0	173.0

^aAnnual estimates based on first three quarters 1975.
^bAdjustment based on analysis of ten-year history of 50 U.S. corporations.
^cFrom Department of Commerce, *Business Conditions Digest*, December 1975.

APPENDIX A

UNITED STATES GOVERNMENT DEPRECIATION COST PRINCIPLES AND PROCEDURES

Following is an excerpt from the Armed Forces Procurement Regulation as of October 1, 1975 which describes Contract Cost Principles and Procedures.

(a) Depreciation is a charge to current operations which distributes the cost of a tangible capital asset, less estimated residual value, over the estimated useful life of the asset in a systematic and logical manner. It does not involve a process of valuation. Useful life has reference to the prospective period of economic usefulness in the particular contractor's operations as distinguished from physical life and shall be evidenced by the actual or estimated retirement and replacement practice of the contractor.

(b) Normal depreciation on a contractor's plant, equipment, and other capital facilities is an allowable element of contract cost *provided* the contractor is able to demonstrate that such costs are reasonable and properly allocable to the contract. Subject to (e) and (f) below:

(i) Depreciation will ordinarily be considered reasonable if the contractor follows depreciation policies and procedures which:

(A) are consistent with the policies and procedures he follows in the same cost center in connection with his business other than Government business;

(B) are reflected in his books of accounts and financial statements; and

(C) are used by him for Federal income tax purposes, and are acceptable for such purposes;

(ii) Where the depreciation reflected on a contractor's books of account and financial statements differs from that used and acceptable for Federal income tax purposes, reimbursement shall be based upon the cost of the asset to the contractor amortized over the estimated useful life of the property using depreciation methods (straight line, sum of the years' digits, etc.) acceptable for income tax purposes. Allowable depreciation shall not exceed the amounts used for book and statement purposes and shall be determined in a manner consistent with the depreciation policies and procedures followed in the same cost center in connection with his business other than Government business.

(iii) Depreciation for reimbursement purposes in the case of tax-exempt organizations shall be determined on the basis outlined in (ii) above.

(c) Special considerations are required for assets acquired prior to the effective date of this principle where, on the effective date of this principle, the undepreciated balance of such assets resulting from depreciation policies and procedures used previously for Government contracts and subcontracts is different from the undepreciated balance of such assets on the books and financial statements. Generally, the undepreciated balance for contract cost purposes shall be depreciated over the remaining life using the methods and lives followed for book purposes. The aggregate depreciation on any asset allowable after the effective date of this 15-205.9 shall not exceed the cost basis of the asset less any depreciation allowed or allowable under prior procurement regulations.

(d) Depreciation should usually be allocated to the contract and other work as an indirect cost. The amount of depreciation allowed in any accounting period may, consistent with the basic objectives set forth in (a) above, vary with volume of production or use of multishift operations.

(e) In the case of emergency facilities covered by certificates of necessity, a contractor may elect to use normal depreciation without requesting a determination of "true depreciation" or may elect to use either normal or "true depreciation" after a determination of "true depreciation" has been made by an Emergency Facilities Depreciation Board. The method elected must be followed consistently throughout the life of the emergency facility. When an election is made to use normal depreciation, the criteria in (b) above shall apply for both the emergency period and the post-emergency period. When an election is made to use "true depreciation", the amount allowable as depreciation:

- (i) with respect to the emergency period (five years), shall be computed in accordance with the determination of the Emergency Facilities Depreciation Board and allocated rateably over the full five year emergency period; *provided* no other allowance is made which would duplicate the factors, such as extraordinary obsolescence, covered by the Board's determination; and
- (ii) after the end of the emergency period, shall be computed by distributing the remaining undepreciated portion of the cost of the emergency facility over the balance of its useful life *provided* the remaining undepreciated portion of such cost shall not include any amount of unrecovered "true depreciation."

(f) No depreciation, rental, or use charge shall be allowed on property acquired at no cost from the Government by contractor or by any division, subsidiary or affiliate of the contractor under a common control.

(g) The depreciation on any item which meets the criteria for allowance at a "price" in accordance with 15-205.22(e) may be based on such price, *provided* the same depreciation policies and procedures are used for costing purposes for all business of the using division, subsidiary or organization under common control.

(h) No depreciation or rental shall be allowed on property fully depreciated by the contractor or by any division, subsidiary or affiliate of the contractor under a common control; however, a reasonable charge for the use of fully depreciated property may be agreed upon and allowed (but see 15-107). In determining this charge, consideration should be given to cost, total estimated useful life at time of negotiation, effect of any increased maintenance charges or decreased efficiency due to age and the amount of depreciation, if any, previously charged to Government contracts or subcontracts.

15-205.10 *Employee Morale, Health, Welfare and Food Service and Dormitory Costs and Credits.* (CWAS)

(a) Employee morale, health and welfare activities are those services or benefits provided by the contractor to its employees to improve working conditions, employer-employee relations, employee morale and employee performance. Such activities include house publications, health or first-aid clinics, recreation, employee counseling services and, for the purpose of this paragraph 15-205.10, food and dormitory services. Food and dormitory services include operating or furnishing facilities for cafeterias, dining rooms, canteens, lunch wagons, vending machines, living accommodations or similar types of services for the contractor's employees at or near the contractor's facilities.

APPENDIX B

WEST GERMAN GOVERNMENT DEPRECIATION COST PRINCIPLES AND PROCEDURES

The following material contains West German Cost Principles as described in *Regulation PR/NO 30/53 on Pricing in Public Contracts*, November 1953, revised November 1961 and December 1967.

Depreciation of Fixed Assets

37. *Definition*

- (1) Depreciation of fixed assets is a cost arising from the reduction in the value of fixed assets required in the contractor's operations.
- (2) The depreciation charge may be determined per unit of time or per unit of output (ton, unit, machine-hour, etc.).

38. *Depreciation Charge and Valuation Method*

- (1) The depreciation charge will be determined independently of the asset values stated in the balance sheet and in tax statements. It is obtained by evenly spreading the cost of acquisition or manufacture of an asset over its useful life. Installation and startup costs are part of the cost of acquisition or manufacture.
- (2) Where the cost of acquisition or manufacture differs substantially from replacement cost, and this is not only a temporary development, and provided that the principle of valuation at replacement cost is consistently adhered to, depreciation charges may be calculated on the basis of
 - a) the cost of acquisition of an equivalent asset at the date specified in subparagraph (3) below instead of the actual cost of acquisition of the asset;
 - b) the cost of manufacture of an equivalent asset at the date specified in subparagraph (3) below instead of the actual cost of manufacture of the asset.
- (3) The following reference dates will be used in determining replacement cost:
 - a) where assets were already in use on 20 June 1948, either 30 August 1948 or 30 August 1949, for whichever date replacement cost is lower;
 - b) where assets were acquired after 20 June 1948, the valuation date.
- (4) Where the lower of the two values referred to in subparagraph (3)a) above cannot be derived directly from the records, it may be determined by a careful estimate taking the higher value as a reference.

39. *Useful Life*

- (1) The useful life of an asset may be expressed as the normal life expectancy of this kind of asset or its estimated output over its expected physical life.
- (2) The estimates of the useful lives of assets or groups of identical assets will be periodically reviewed. Where depreciation charges are found to have been excessive or insufficient, they will be charged or credited, as appropriate, to depreciation contingencies subject to the provisions of paragraphs

49(3) and 50 below. The contracting public agency and the contractor may agree otherwise.

- (3) Where the elapsed portion of the useful life of an asset cannot be clearly determined, its estimated residual value (value as new at current prices less past depreciation) may be used as a basis for computing the depreciation charge.

40. *Adjustment of Replacement Value*

Where the replacement value of an asset (according to paragraph 38(2) above) is used as a basis for determining the depreciation charge, this replacement value will be adjusted to reflect the reduced efficiency of the actual asset as compared with that of an equivalent replacement asset.

41. *Special Depreciation Charges*

Depreciation charges (according to paragraphs 38 to 40 above) may be exceeded to make allowance for an unforeseeable technological development, shift in demand or for other reasons (special depreciation charges), provided that the contracting public agency expressly agrees to such higher depreciation charges. Special depreciation charges (according to the first sentence of this paragraph) will be disclosed separately.

42. *Records of Fixed Assets*

- (1) Records of all fixed assets will be maintained containing all data relevant to depreciation, in particular initial values, estimated useful lives, useful life elapsed to date, depreciation charges per unit of time or output and residual values.
- (2) A separate record will be maintained for each individual asset, provided, however, that identical assets of identical initial value or of low value may be grouped together.
- (3) Where the contracting public agency so requests, the contractor will substantiate replacement values (according to paragraph 38(2) above) and adjustments computed according to paragraph 40 above.

SOME THOUGHTS ON CIVIL AVIATION R&D POLICY

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(Prepared for the Subcommittee on Aviation and Transportation Research and Development, Committee on Science and Technology, U. S. House of Representatives, April, 1976)

This brief presentation will consider civil aviation R&D policy. Some available civil aviation R&D policy reports will first be listed. The historic role of the Federal Government in civil aviation will then be quickly examined. The scope and responsibility of Federal R&D efforts is next illustrated, followed by an overview of current attempts to coordinate civil aviation R&D activity. The presentation closes with a description of some proposed R&D priorities, a quick look at development costs, and a summary.

Background

Civil aviation has had a major influence on the way of life in the United States. The products of civil aviation research and development (R&D) have increased airline and general aviation productivity and have made air travel a safe, efficient, and economic mode of transport in this country and elsewhere. Civil aviation R&D efforts have also contributed a great deal to the leadership this country enjoys in world civil aviation. In addition the civil aviation manufacturing industry's contribution to the U. S. Balance of Trade has been noteworthy. In order for the U. S. to continue its leadership in civil aviation, an effective coordinated R&D program is a necessity. The question is of course how does one achieve an effective and coordinated civil aviation R&D program.

Concern over civil aviation R&D policy is not new; it dates back for at least ten years or more. In May 1966 the Congress recognizing the need for examining civil aviation R&D policy commissioned a staff report titled "Policy Planning for Aeronautical Research and Development" prepared for the Committee on Aeronautical and Space Sciences, United States Senate, Senate Document 90, 89th Congress, 2nd Session.

In August 1968 the National Academy of Engineering issued a Summary Report titled "Civil Aviation Research and Development - An Assessment of Federal Government Involvement," Washington, D. C.

In 1968 the concern of the U. S. Department of Transportation (DOT) regarding the ability of the airways system to accommodate future growth in traffic safety and efficiency led to the formation of a Department of Transportation Air Traffic Control Advisory Committee. In December 1969 that Committee prepared a report outlining the R&D required to handle air traffic through the early 1980's. This report provided a framework for R&D policy for air traffic control and air traffic management within the Federal Aviation Administration (FAA).

In March 1970 the Subcommittee on Advanced Research and Technology of the Committee on Science and Astronautics, U. S. House of Representatives, issued a report titled "Issues and Directions for Aeronautical Research and Development," House Report 91-932, 91st Congress, 2nd Session.

Also in 1970 in response to a recommendation by the Senate Committee on Aeronautical and Space Sciences (90th Congress), for "an in-depth study--to analyze, the benefits that accrue to the Nation from aviation and the level of aeronautical R&D effort" a civil aviation research and

development policy study was undertaken jointly by the Department of Transportation and the National Aeronautics and Space Administration. A report titled "Civil Aviation Research and Development Policy Study" was issued in March of 1971.

The Federal Government's Historic Role in Civil Aviation

Early in aviation's history Federal Government policy favored R&D support, and R&D efforts by the Federal Government have as a consequence contributed substantially to the growth of civil aviation. It is because of this continuing policy that Federally sponsored research and development in civil aviation has become so extensive.

As a result of the government's aviation support policies a National Advisory Committee on Aeronautics (NACA), was created. NACA was involved in basic research for all segments of aviation, both civil and military. Over the years a unique relationship was established between the air transport industry and NACA which has resulted in substantial benefits to the public. Nothing comparable exists, for example, in the automotive industry.

Substantial commitments of Federal funds to aviation R&D really began with the period following World War II. At this time the military was heavily involved in aviation, and many of the R&D programs funded by the Department of Defense (DOD) had considerable civilian applications. Thus, the civilian sector benefited greatly from the R&D efforts of the military. But the applicability of DOD aeronautical research to civil aviation has decreased substantially; therefore, continued reliance by the civilian sector on military aviation R&D would be unwise.

In the early years of aviation R&D the major emphasis was on aircraft technology. NASA continues to be the major contributor in this area. Later, in the early 1960's, when passenger traffic began to experience substantial gains, R&D efforts were expanded to include aids to navigation and air traffic control and the safety and capacity implications related to these activities. Research efforts on airport improvements were minimal, limited to a few projects on the airside (i.e., exit taxiways, lighting) of the airport. Most recently, as a result of a study by the Federal Aviation Administration for the Congress, there is concern that the landside (i.e., passenger terminal buildings, parking, etc.) portion of the airport will be a significant constraint on airport development and there are indications that in the future Federal R&D funds may be funneled in this direction.

Scope and Responsibility of Federal R&D Efforts

The bulk of R&D efforts in civil aviation have been channeled into three main areas: (1) aircraft technology (2) aids to navigation and air traffic control and (3) ground support facilities such as airports. The R&D in each of these areas can be further subdivided (1) hardware (2) environmental impact (i.e., noise, pollution) (3) cost-effectiveness, and (4) operational considerations primarily as they affect safety.

Aircraft technology, such as vehicles and propulsion, has over time received the major share of R&D funds, followed by aids to navigation and air traffic control. Airport and airport related problems have received minimal support when compared with the other two categories although recently more support has been directed to these problems.

R&D funding for assessing the institutional and regulatory impacts on development of civil aviation as well as for problems related to financing of vehicles and facilities has also been minimal (i.e., questions such as, how can the huge capital investment required to replace the existing airline fleet be raised? have not been fully considered).

Within the Federal Government the responsibility for civil aviation R&D is divided principally among NASA and the Federal Aviation Administration (FAA). The Environmental Protection Agency (EPA) the Energy Research and Development Administration (ERDA) also do some support work. Each of these agencies has its supporters in industry and in Congress and each attempts to justify its R&D budget with the backing of its supporters.

NASA's principal role is in aircraft technology (flight vehicles and propulsion), often referred to as "aeronautics." NASA's aeronautical research program has been established to perform basic research and to promote advances in the state of the art. Its mission is to provide facts and data which need to be established before advanced transportation modes can be developed. In more recent years, NASA's spectrum of research in civil aviation R&D has widened to include a broad range of activities in support of its basic mission (i.e., forecasts of passengers for short haul operations, technology assessment of intercity transportation).

The FAA's major R&D activity has focused on the development of new technologies in air traffic control. A substantial part of the R&D budget has been devoted to upgrading the Third Generation Air Traffic

Control System. R&D support for ground facilities has been minimal, although more recognition has been given to this area in recent years. In contrast with NASA's basic research activity, most of the FAA's efforts can be categorized as applied research on operational problems. Most of the FAA's research and development is performed by private industry, although some support is provided by the Transportation System Center at Cambridge Massachusetts and the Office of the Secretary of Transportation.

Within the Department of Defense the Air Force dominates the aeronautical R&D budget. The military aeronautical program with potential civil applications are, as noted, fewer in number, but some still exist and will be useful to civil aviation, the V/STOL and B-1 programs, for example. Nearly all of the DOD aeronautical R&D funding is channeled toward aircraft technology and very little to anything else (i.e., runway pavements).

Focus of Civil Aviation R&D Efforts

For many years the focus of civil aviation R&D was on safety and improvements to aircraft both in terms of performance and level of service with only a modest emphasis on environmental impact. The underlying objective was to develop a safe aircraft with an acceptable level of service and at reasonable operating cost. If equal or better service could be provided at less cost, the undertaking had a high probability of being a winner. This was the principal goal of the major airframe and engine manufacturers as evidenced by the development of the wide body jets. When the country became more aroused about degradation of the environment and the conservation of energy, more emphasis was placed

on energy conservation and noise and pollution reduction. No longer can a manufacturer strive to reduce operating costs solely by increasing operational efficiency without regard to noise and pollution. Thus it is becoming increasingly more difficult to improve the level of service and at the same time reduce operating costs. A striking example is today's SST which with the exception of speed does not meet any of the criteria I have just mentioned.

A problem facing the aircraft manufacturing industry, therefore, is how to develop aircraft so attractive to the airlines (in terms of level of service, operating cost, and reduced noise) that they will accelerate the disposition of their existing fleets and buy new aircraft. R&D priorities should be directed toward this achievement since it will help all concerned: the airlines, the traveller, and the people on the ground subjected to aircraft noise, and pollution.

Having an aircraft that is attractive both from the standpoint of operating cost and environmental impact is only part of the problem.

The aircraft must be able to fly in an environment that is acceptable to the passenger and aircraft operator. In several Federal reports of recent origin it has been suggested that ground facilities will be a major constraint to the growth of civil aviation. As an example, it does little good to embark on a large scale program of fuel conserving propulsion system if at the same time the aircraft that use these engines are required to wait long periods of time to land at congested airports. This example points out the need for a balanced civil aviation R&D program.

Coordination of Civil Aviation R&D Activity

As noted, the Federal responsibility for civil aviation R&D is vested in several agencies primarily NASA and FAA. On April 21, 1965, in order to coordinate the aeronautical research and development activities of NASA and FAA the NASA-FAA Coordinating Board was established by joint agreement of the two agencies. NASA had a similar agreement with DOD dating earlier. While this is a step in the right direction it leaves a great deal to be desired with respect to establishing priorities for R&D efforts for the total civil air transport system. For example, NASA, because of its basic mission, concentrates on aeronautical R&D; FAA is concerned mostly with air traffic control with modest efforts on other parts of the system. The priorities for R&D are, however established by each agency (with input from industry) without regard to the requirements of the total air transport system. Thus the recent effort by NASA to determine potential R&D areas to the year of 2000 ("Outlook for Aeronautics") is slanted toward aeronautical as opposed to air transport system research (no criticism of NASA is here implied). But who is to say whether an R&D effort within FAA has a higher or lower priority than a program proposed by NASA or any other Federal agency for that matter? Thus there is no effective mechanism at the Federal level to establish R&D priorities for government sponsored research. The long range needs of the entire air transportation system in the United States are consequently not very well coordinated. If such a priority-establishing mechanism could be developed it would also reduce the amount of duplication and waste in R&D efforts. The establishment of an inter-agency R&D coordinating group to establish overall priorities might, then, be useful for your Committee to consider.

R&D Priorities

I can only describe in general the areas of R&D that deserve attention. These are:

(1) Noise. Aircraft noise abatement deserves very high priority because of widespread concern for the environment and also because of its potential limiting effect on the capacity of the air transport system (i.e. curfews).

(2) Aeronautical (Hardware). This category represents many R&D programs which should be aimed toward improvement of aircraft efficiency and reduction of aircraft operating costs. The achievement of this goal will provide airlines with an incentive to replace older aircraft thus benefiting society as a whole.

(3) Safety. As always research related to improved safety of flight vehicles deserves high priority.

(4) Air Traffic Control and Aids to Navigation. The objective here is to reduce delay, enhance safety and reduce environmental impacts whenever possible. Because of the high cost involved in some of the projects only a few programs are now being funded from available R&D funds.

(5) Ground Support Facilities. As noted, there is a concern that lack of adequate ground support facilities (i.e., runways, passenger processing facilities, parking, access) may be a major constraint in the development of civil aviation. The current adverse attitude toward new airport development requires that the efficiency of our existing support facilities be improved so that their capacities may

increase to accommodate future growth. As stated earlier, the amount of funding in this area has been minimal and requires more support.

(6) Institutions and Regulation. Institutional forces often constrain the development of transportation. The impact of introducing new ways of doing things can "cause changes in institutions or institutional relationships, but there is an inertia to these relationships that can serve as a formidable barrier to change. This situation will continue to be important in the future. Therefore, there needs to be a better understanding of how to evaluate the institutional forces that may effect the growth of civil aviation." Regulation has played, and will continue to play, an important role in the development of civil aviation. Thus there is a need to develop techniques for assessing possible impacts due to regulatory changes (i.e. decisions by airlines to acquire new fleets are significantly affected by the regulatory climate).

(7) Financing. Funding constraints are posing increasingly severe problems that must be solved before major improvements in civil aviation can be made. One of the major constraints to the replacement of existing noisy and fuel-inefficient aircraft with new aircraft that are far less noisy and more fuel efficient is the ability of the airlines to raise sufficient capital for this purpose. Other parts of the air transport system also suffer from lack of capital. "Studies to quantify short and long term financing problems in civil aviation and to identify, or advise, new funding mechanisms" is desirable.

The seven categories of research just listed include a large number of programs requiring a large amount of money. To avoid doing research

merely for the sake of doing research , and before large sums of money are committed, each large program should be critically examined to determine the potential benefits and costs to the users.

Development Costs

Development costs are much larger than the cost of research. There has always been a strong push from researchers for money to continue projects into the development stage without too much concern as to exactly where the final application will occur. Since the development programs will cost many more times the amount of the original research the selection of candidate programs is an extremely important consideration in R&D.

There is always a risk involved in funding research and development in that there may be no immediate payoff. Applied research should, however, be encouraged to take such risks in the development of a few selected techniques and devices, they being put on the shelf for a while if no immediate operational use is found. Such a policy is necessary for a healthy research program. On the other hand the continuance of a development program that shows very little promise of adoption is of course unwise, though this is often done to maintain staff -- "the place would shut down if we did not have this going."

There is another aspect of development costs that appears to me worthy of Committee consideration from a policy point of view. In the United States development costs for a specific piece of operational hardware (i.e., jet engine, commercial airliner) have been borne by the manufacturer of the product and recouped through the sales of the product. This approach has been successful as long as the cost of

development could be financed by the manufacturer. Today the development costs of some products (i.e., jet engines, new airplanes) are often far greater than the net worth of the manufacturer. This has forced some of our manufacturers to go into partnership with foreign firms to ease the financial risks. In contrast some foreign governments directly support their aviation manufacturers, citing that such support is of value for balance of payments, employment, etc. Major development cost questions are, then, to what extent should such a policy be adopted in the United States and what type of support should be considered?

Summary

Continued government support for research and development is absolutely necessary to meet the future requirements of civil aviation. Currently the responsibility for carrying out R&D in the Federal Government is vested among several agencies (NASA, FAA, EPA, ERDA), each with its own budget. While these agencies have been doing a good job there is no effective mechanism to establish R&D priorities for civil air transportation considering the system as a whole, since no single agency has the responsibility for the entire system. To avoid disjointed R&D programs, overall coordination of activities is required to establish meaningful programs and their respective priorities. While some attempts have been made to coordinate programs among several agencies the results so far have not achieved a well balanced integrated civil aviation R&D program that takes into account the entire air transport system (door to door). What is needed is to identify those programs where payoffs are needed as quickly as possible and to separate them from programs of lesser urgency (i.e. reduction or elimination of wake vortices compared with

propulsion systems for hypersonic flight). Once these programs are indentified priorities need to be established (i.e., does the Aerosat program or the STOL program have higher, lower, or equal priority with research on runway, taxiway, and apron pavement design?).

A major focus of civil aviation R&D in terms of funding is on aircraft technology. R&D on airports and airport related problems, and the assessment of institutional and regulatory impacts on development of civil aviation, have been minimal. More funds are required for these endeavors. Likewise, studies to quantify short and long term financing problems in civil aviation and to identify, or devise, new funding mechanisms are desirable.

The high cost of developing major pieces of hardware (i.e., aircraft propulsion systems) precludes manufacturers from undertaking potentially risky hardware development ventures, a situation which requires an examination of the required role of government in support of such ventures, as is being done in other countries.



UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

May 17, 1976

Honorable Dale Milford, Chairman
Subcommittee on Aviation and
Transportation R&D
Committee on Science and Technology
House of Representatives

Dear Mr. Milford:

In accordance with the request of Ralph Read, I'm pleased to expand on the comments in my letter of April 16, 1976 and submit the enclosed paper on the "Case for an Increased Program of Research and Development in Air Traffic Control."

Sincerely,

~~David R. Israel~~
Technical Assistant to
the Administrator

Enclosure:
As stated



THE FUTURE OF AVIATION: THE CASE FOR AN INCREASED
PROGRAM OF RESEARCH AND DEVELOPMENT IN AIR TRAFFIC CONTROL

By

David R. Israel
Technical Assistant to the Administrator
Energy Research and Development Administration

(Formerly Deputy Associate Administrator
for Engineering and Development,
Federal Aviation Administration)

May 17, 1976

In the early 1970's and largely as a result of the report of the Department of Transportation's Air Traffic Control Advisory Committee, the strong position taken in House Report 91-1308 on "Problems Confronting the Federal Aviation Administration in the Development of an Air Traffic Control System for the 1970's" and the establishment of the Airport and Airways Trust Fund, the FAA's research and development (R&D) program was substantially upgraded. From bare subsistence levels in the late 1960's, the associated R&D budget rose rapidly past \$50 million and approached \$100 million. However, the budget has leveled off at about \$75 million in the past few years despite the continuing pressures of inflation and the necessary commitment of large portions of this funding to the preproduction or preoperational phases of successful R&D projects of several years earlier. Of significance is the fact that some voices in the aviation community are calling for reductions in the FAA's R&D budget, or even the elimination of that function.

It is my very strong conviction, based on some 25 years involvement in the air traffic control field and five recent years in the direction of the FAA development programs, that the future growth and record of civil aviation in the United States could be adversely affected unless this trend in funding is reversed and a strong and effective R&D program in air traffic control equipment and systems is again established. As a means of conveying this concern, I have prepared and answered what I believe to be the basic questions which must be addressed.

1. Should our national policy include constraints to the growth of civil aviation?

No. Except when safety or the environment is endangered, national aviation policy and plans should avoid any direct economic, energy, regulatory, or other constraints to the continued growth of civil aviation. Aggressive programs should be taken to preclude such future constraints.

2. If unrestrained, what traffic growths can be anticipated?

Economic and other analyses generally point to a continued long-term growth of commercial passenger miles in the range of 5-8% per year. Varying growth rates are expected for the different types of general aviation flight activity. Overall, the annual growth in flight activity measures which affect the air traffic system should be in the 4-6% range.

3. What is the expected impact of such a growth rate?

Unless constrained, there will be a doubling of most measures of aviation activity over the next 10-15 years, with general aviation becoming the largest customer of the national aviation system at about the end of this time period. This doubling is particularly significant since many other factors directly involved in the performance of the national aviation system will not change or are already severely constrained. For example, it is not anticipated that the numbers of commercial airports will increase significantly or that new airports will be built;

some runways will be added at existing airports, but this is probably only in the range of a few percent increase. Future traffic will use the same basic routes and the same altitudes will be in demand; the radio frequency spectrum will not increase and will find itself in growing short supply. Further, the public expectation of the performance of the system in terms of delays and safety levels is not likely to be relaxed. To provide a doubling of capacity of the air traffic control system under such conditions is a formidable task. System capacity and performance thus may constrain future aviation growth.

4. What is needed to remove or reduce the possibility that the air traffic control system will be a constraint to future air traffic growth?

The capacity and productivity of the existing system must be increased. This includes the enroute air space, approach and landing air space, and the airport surface itself, and, most important, improvements in the productivity of the operating and maintenance personnel in centers, towers, and flight service stations.

5. Can we achieve the necessary productivity improvements?

There is no guarantee, in fact, that this can be achieved. However, without a major program of research, development, test and evaluation it is clear that improvements will not be forthcoming.

6. Are there realistic alternatives to the present ground-based and organized air traffic control system?

No. The advancement of the state-of-the-art in electronics, communications, lasers, satellites, and related fields offers many new and interesting possibilities for the collection, processing, and transmission of air traffic control information. However, no reputable study of the alternatives to an integrated ground-based air traffic control system has indicated any solution which is simpler, less expensive, and provides greater performance. The simple fact of the large capital investment in both ground-based and airborne equipments coupled with the history of air traffic control clearly indicates that the future system will be an evolution and upgrading of the existing one.

7. Who should undertake this R&D program?

In previous years, there have been proposals that the conduct of air traffic control R&D should, for any of several reasons, be removed from the FAA and placed under the Office of the Secretary of Transportation, in NASA, or in a new organization. Any such move would be a significant mistake. Air traffic control R&D must be done in concert with the operator and users of the system. An innovative R&D program cannot be achieved if there are undue constraints from system operators and users; on the other hand, a successful program requires the continuing influence of their needs, requirements, and day-to-day operating problems. The R&D cannot be done "in spite" of the FAA; it can and should be done within the FAA.

This is not to say that the efficiency of the FAA's ATC R&D programs could not be improved. To do so will require several steps, but key among them must be an increased recognition within the FAA itself of the importance of the R&D function to system growth and well-being. Financial upgrading of the program and attraction of superior R&D personnel from outside the FAA, on a temporary or permanent basis, should be two goals.

8. Of what importance is the generally negative attitude of users of the air space to more, if any, ATC R&D?

The users of the air space are not a single homogeneous group, but rather consist of different groups distinguished by major differences in types of operation, objectives, and philosophy. Air traffic control means air space rules, some restrictions to flight, and additional airborne equipment--all of which represents a "cost" to the air space users. The "cost" will clearly increase as the growing traffic loads cause increased congestion. The air space users, however, take a rather short-term perspective which is highly influenced by current economic considerations. Air traffic control R&D is thus viewed as a source of increased "cost", rather than long-term relief, and is opposed except where it contributes to unique problems of a specific user group. The attitude of user groups must be accepted and understood.

9. What is the appropriate level and source of funds for the necessary R&D program?

It would be wrong to constrain the funding to some arbitrary level, as has been suggested by some in the aviation community. Rather, it should be set to a level consistent with the projected growth of traffic or to a level predicated on the appropriate needs in any given year. The term R&D does not properly convey the scope of the necessary program; the words research, development, and demonstration (RD&D) more fully present the problem. The FAA has reached the big systems era, and the development and evaluation of breadboards, then prototypes, and finally pre-production versions of such systems is very expensive. If the final evaluation of prototypes or production versions--a pre-operational expense--is charged to normal R&D accounts, little will be left for applied research and advanced development of new technologies. This is the situation today, where the heavy cost of MLS, DABS, IPC, and AEROSAT has left insufficient funds for other key areas. Until agreement is reached on raising the conventional R&D budget accordingly, such pre-operational expenses should be charged to implementation accounts (as was done in the past).

In summary, a strong and effective program of air traffic control R&D should be funded and organized within the FAA if the system itself is to meet national needs and not present a constraint to the continued growth of civil aviation.



UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

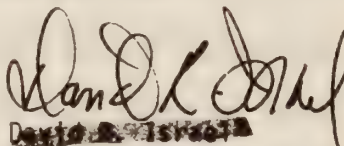
May 17, 1976

Honorable Dale Milford, Chairman
Subcommittee on Aviation and
Transportation R&D
Committee on Science and Technology
House of Representatives

Dear Mr. Milford:

As a follow-up to his letter of May 4, 1976, Dr. Seamans has asked me to forward the enclosed paper presenting the views of the Energy Research and Development Administration on Energy and Aviation. If we can be of further assistance in your important task, please do not hesitate in asking.

Sincerely,


~~David A. Israel~~
Technical Assistant to
the Administrator

Enclosure:
As stated



Views of the Energy Research and Development Administration
on Energy and Aviation

A. ENERGY CONSUMPTION

The importance of aviation as a consumer of energy can be illustrated by examining available energy consumption patterns. Numerous sources, although varying in detail, generally attribute 25% of the Nation's total energy demand to the field of transportation. Since transportation is almost entirely dependent on the use of petroleum-based fuels and consumes approximately 55% of all petroleum used in the U.S., any energy program seeking to reduce this Nation's dependency on petroleum imports must consider transportation as a major factor.

The present distribution of energy consumption within transportation (Figure 1) identifies the automobile as the primary user of energy, with over half of the transportation total attributed to it. Other highway vehicles (trucks and buses) utilize approximately 25% of the transportation energy consumption, with the remaining 25% distributed among the non-highway systems including aircraft, pipelines, ships and railroads.

While it is obvious that the automobile, as the most significant transportation energy consumer, should be and is the primary ERDA target for transportation conservation, other transportation modes

KEY ELEMENTS OF THE TRANSPORTATION SECTOR

	<u>% of Transportation Energy Consumed - 1971</u>
Automobiles	52
Trucks	22
Aircraft	10
Pipeline	6
Ship	4
Rail	3
Bus	1
Other	2

such as aircraft at about 10% still consume large enough quantities of petroleum-derived fuels to be of considerable interest. As an example, DOT Energy Statistics (1974) indicate over 11 billion gallons of fuel were expended by certified air carriers and general aviation in 1972.

Additionally, the past history of aviation shows that this transportation mode has experienced a rate of growth far in excess of that sustained in other modes. Expansion in aviation energy consumption increased at a rate of about 11% in the years from 1963 to 1973. Extrapolation of this growth rate into the future would easily convert aviation from its current modest role into the dominant factor in future transportation energy consumption patterns. However, it is believed that most of the passenger shift to aviation from other transportation modes has already taken place and the best available current projections predict continued growth rates of 4 to 8% annually. Still, these rates, which are high in relation to the rest of the transportation industry, do tend with time to increase the importance of aviation as an energy consumer and represent one of the major uncertainties in future transportation energy consumption patterns illustrates this uncertainty by projecting aviation consumption as varying from a high of 33.2% of transportation by the year 2000 to a low of 20.1%. It should be noted that even the lowest of these projections represents the year 2000 aviation energy

demand as twice as large as that currently experienced. Thus, aviation is an area that must be accounted for in any effective program aimed at achieving reduced national petroleum dependency.

B. AVIATION ENERGY R&D PROGRAM

The R&D approaches toward meeting aviation energy requirements can in general be placed into two categories: (1) those efforts aimed at reducing energy consumption by attaining improved efficiency of fuel conversion or increased productivity per unit of energy consumed and (2) those programs designed to provide alternate energy sources which while not necessarily reducing energy consumption will decrease dependency on petroleum-derived fuels.

A survey of activity in the former category indicates that a number of government agencies are currently supporting aviation energy conservation programs. ERDA efforts to develop improved efficiency automotive engines may have some application to general aviation aircraft. Technology improvements in the three major areas of propulsion, aerodynamics and structures are being sought through the NASA Aircraft Energy Efficiency Program. The Department of Defense continues a high level of support for aircraft technology which while not primarily energy motivated is expected to provide related

energy effective advances. These programs and others of a similar nature may have some near-term application and energy payoff, but for the most part are considered to be principally effective in the long term with significant energy savings likely to be achieved only as we approach the year 2000.

Shorter range improvements in efficiency or productivity can be attained through other approaches such as those associated with improving aviation flight operations. These are primarily the province of FAA or the Air Transport Association for the airlines. Some examples are: (1) the FAA program on area navigation is expected to achieve future fuel savings of 38,000 barrels of petroleum per day through improved air traffic control, (2) a recent FAA test of a fuel advisory departure procedure is reported to have saved the airlines about 650,000 gallons of fuel during a one-day trial involving Chicago-bound flights, and (3) airline policy decisions to increase load factors from a baseline average of 58% to a level of 65% could achieve a 10% savings in fuel consumption according to a recent NASA-sponsored McDonnell-Douglas Aircraft study.

In the second category, alternate energy sources, the major problem to be faced is to identify and characterize the potential alternative

fuels most likely to be available for use on aircraft in the near-and far-term and to determine the research and development support necessary to make those fuels viable alternatives to the aircraft industry. It is popular to believe that aviation will warrant a sufficiently high priority to have an early call on available petroleum derived fuel stocks in the event of future shortages. This, however, is by no means a certainty. Consequently, the availability of alternate fuels may become vital at some point in the future to the ability of the airlines to operate, as well as being a major factor in achieving petroleum independence if aviation energy consumption continues to grow as generally predicted.

Fuels likely to be candidates for aviation use include coal-, shale-, and tar-sand-derived syncrudes, hydrogen and various blends. While a number of programs in alternate fuels are being actively pursued within the Department of Defense and NASA, it is apparent that many technical and economic problems must be overcome before there are any new fuel options for future use. Typical recent programs include: (1) a NASA study of the application of hydrogen fuel to long-range subsonic transport aircraft, (2) a cooperative DOD-NASA program leading toward the qualification of syncrude fuels for aviation which included the successful flight of an Air Force plane on shale-derived fuels and

(3) a NASA study on the conversion of coal to hydrogen, methane and liquid fuels for aircraft.

ERDA ROLE

As cited in the Energy Reorganization Act of 1974, ERDA is responsible for "encouraging and conducting research and development in energy conservation which shall be directed toward the goals of reducing total energy consumption to the maximum practicable and toward maximum possible improvement in the efficiency of energy use." Insofar as transportation is concerned, ERDA is responsible for establishing an overall National Plan to determine energy conservation goals, to identify current and planned related programs of other agencies and industry, and to encourage or conduct further development, demonstration or commercialization required to achieve the conservation goals.

The formulation and implementation of such a plan requires the establishment of close working relationships with those other involved government agencies. The mechanism of a memorandum of understanding (MOU) is being used to formalize these working relationships and to describe general policy and management approaches which will govern planning, approval and conduct of RD&D programs of mutual interest. A recently effected MOU between DOT and ERDA is typical of those

being sought and states the policy of the two agencies as being one of working together "...in mutually supporting ways in the formulation and execution of RD&D programs aimed at meeting the goal of reduced energy consumption in the transportation sector." An MOU has been executed with NASA and another is being negotiated with the Department of Defense. Both of these will ensure close collaboration between ERDA and with regard to aviation energy conservation and programs directed toward alternate fuels.

May 12, 1976

Hon. Dale Milford
Chairman
Subcommittee on Aviation and
Transportation R&D
Committee on Science & Technology
U. S. House of Representatives
Suite 2321, Rayburn House Office Building
Washington, D. C. 20515

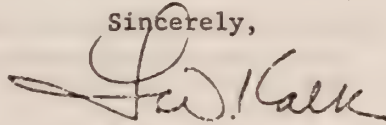
References: 1. Your letter of April 9.
2. My letter to you of April 20.

Dear Congressman Milford:

Attached for your use in the Committee's examination of the "Future of Aviation" is a copy of my thoughts on the subject.

Again, thank you for the opportunity to participate and if I can be of any further service to you or the other members of the Committee, please don't hesitate to let me know.

Sincerely,

A handwritten signature in dark ink, appearing to read "F. W. Kolk", with a stylized flourish at the end.

F. W. Kolk
Vice President
Technological Development

Statement Of

Mr. Franklin W. Kolk
Vice President - Technological Development
AMERICAN AIRLINES, INC.

Concerning the
"FUTURE OF AVIATION"

Submitted to
SUBCOMMITTEE ON AVIATION AND TRANSPORTATION RESEARCH & DEVELOPMENT
Committee on Science & Technology
U.S. House of Representatives

May 17, 1976

-1-

My name is Franklin W. Kolk, Vice President of Technological Development for American Airlines. I am very pleased by the invitation extended by the Subcommittee on Aeronautical Research & Development to submit my comments concerning the future of aviation.

My views, quite frankly, are biased by my thirty-three years experience in the airline business and by the basic character of this business throughout its history of development. Air transportation is a maturing industry in terms of the fact that the spectacular growth rate of 15% to 20% experienced prior to 1970 has leveled off to approximately 5% during the ensuing years. Airlines have, however, grown up under conditions rather different from most other industries. These conditions must go a long way towards explaining the situation we find ourselves in today. From the beginning airline operators have always been marginal. It is safe to say that nothing but inherent optimism sustained the early group of carriers from the time of their founding until the mid-1930's, when the combination of available technology and proper sizing produced the DC-3 airplane—the first transport which earned any noticeable profits for any of the carriers. I believe these two basic factors, i.e. proper sizing and appropriate available technology, continued to create the growth of the American carriers from that day to the present. I will not waste the time and space to produce a detailed history of this evolution, however, suffice it to say that the airlines grew up in an atmosphere of increasing aircraft range, increasing aircraft speed, and decreasing unit production costs—the latter achieved to a great extent through the increase in the unit size of the airplane.

All through this time, the industry has been supported by technological development largely supplied by the military establishment, i.e. until approximately the latter part of the 1950's. From that time, many of the technological requirements for civil air transports diverged quite radically from the military requirements and more laterally the space exploration requirements. Hence, it is fair to say that for the past two decades, civil transportation has not had available to it, the high risk technologies that were available and largely originated in NACA as well as NASA during its past history. There is no doubt about it, the contributions in the past were magnificent and without these contributions the American civil air transportation system with its magnificent safety record and high efficiency simply would not exist.

Today, in retrospect, one finds that the airline industry and its suppliers, the related manufacturing industry, are in a position of having run out of ideas. We cannot improve the efficiency by increasing the speed of aircraft or reducing block time. If nothing else, the supersonic transport has confirmed this fact. Also, due to the energy crisis in the past few years, we have actually reduced the operating speed of our aircraft to save fuel. Secondly, we cannot on a large scale, exploit increases in available range. The industry achieved non-stop U.S. transcontinental operation many years ago and has also achieved non-stop flight overseas to the extent that some existing aircraft types have sufficient range to operate between virtually any possible city pair which have sufficient populations and other

mutual attractiveness to support non-stop flight. Thirdly, the industry has sufficiently exploited unit size to the point where our problem now is one where airplane capacity has grown too large and it is virtually impossible to assemble very many payloads of the size which warrants the very large airplanes, except on a few segments where frequency limitations exist. We have extended the useful life of individual aircraft to the point where 50,000 hours of service is not uncommon, and because of recent inflationary pressures, the need to replace units has diminished. A trend is developing to replace units not because the replacement is more economical by virtue of its inherent design and technology, but because the maintenance implications of these elderly aircraft are becoming more significant. In fact, we have invented a new term which speaks for itself. We now talk about airplane geriatrics.

Because of the relatively slower turnover in aircraft in service, the opportunity to introduce new fleet types becomes less and less and the temptation to replace the existing aircraft with another of the same design family increases. All of this means that there is a body of technology available to us which we are not utilizing.

There is a strong temptation to simply throw up ones hands at this juncture and say that we do not have any technological problems but rather an economics problem. The essential feature of airlines is unchanged. They run on a very low profit margin and a very high proportion of the airline expenditure is for fuel and labor. In this respect they are unique. Because the airlines provide journeys of vast distances, the individual ticket costs tend to be high and there is a growing consumer pressure to lower the fares. In the current scenario this has

produced some startling financial losses under some unexpected conditions, and in recent years has produced a situation where no common carrier airline has ever made a profit which would be regarded as respectable in most industries. Yet, today there are groups within government and the private sector that believe they are experts on airline economics even more so than the airlines. This is fallacious, and without some very strong leadership in the Congress, it is possible that the airlines as we now know them will gradually disappear. Hence, my first major point is, that all the technology in the world is not going to stop this "leaking dam" without an adequate and understanding approach to basic airline economics by the people and Congress of the United States.

Assuming that this problem can be solved, let us turn to some of the technical thrusts which might be of great assistance. The basic problem is to have airplanes which operate for less money per seat mile without basically increasing the size, speed, or range of the aircraft. This means an examination of where the money goes and an attempt by scientists to create technologies that reduce this money flow. NASA has come up with a number of areas where they feel money can be saved. The most important of these areas is fuel. There have been a number of suggestions as to what would cumulatively save significant amounts of fuel burn in transport type aircraft. Most of these are embodied in the Kramer Report and these various strategies have been examined for practicality for the past year and a half. None of the ideas are new. Some of them have been kicking around for as much as thirty years but have never found practical application. Among these are: sucking type

boundary layer control on wing surfaces, aft C.G. achieved by reactive controls, reduction in specific fuel consumption by going back to turboprops, the use of composites in primary structure to save weight, the use of more efficient wing sections to reduce drag, etc. Passing the introduction of these technologies is the question of whether they will work and whether they will needlessly increase the risk of flying. In virtually every case that produces major results, it must be introduced in good faith on a new airplane type. The opportunity of retrofit does not exist. Very significant claims have been made for some of these technologies, but their achievements have never been properly demonstrated nor will they ever be demonstrated unless someone spends a tremendous amount of money in good faith on not just one but a whole fleet type of aircraft. Yet, today even though our system is good enough and refined enough, the responsible people in the various industries and crafts are reluctant to go after the new technologies in an uninhibited way. In the case of reactive controls and an optimum aft C.G., for instance, the first problem is the reluctance of anyone in the system to commit to consider an airplane in which total failure of the reactive control system will render the airplane unworthy and, therefore, subject to crashing immediately. The attack is to sacrifice half of the benefit so that the airplane can be flown back home safely providing there is a total failure of the control system. This is an old problem and has been dealt with in the past in a number of different ways. I understand, for instance, that the much maligned Concorde SST possesses the reactive control system and in certain phases of the flight would be unmanageable at supersonic speeds without

-6-

this type of system, yet the philosophical and engineering difficulties have been faced on this aircraft and there has been no particular complaint in the use of this principle. The point I am making is that some innovative thinking needs to be done in the application of these principles to new aircraft designs. The other point is, they will never be applied unless the climate is made favorable for the construction of a new aircraft type. Yet the combination of natural economics and bureaucratic rigidity has rendered the credit of the airlines sufficiently assunder so that no one in the cycle has access to the capital required to launch a new aircraft project, much as it is needed.

The foregoing discussion is typical of the technological position in a number of areas. Yet, all of the ideas that have been discussed up until now have not only been originated but brought to some degree of refinement in NACA and its successor NASA. The military technology picture has obviously a great parallel. The military has become extremely project oriented. As a matter of fact, so has the civil sector. This has resulted in a situation where most of the money, most of the encouragement, and most of the support is associated with project oriented work. The idea of going out and thinking up something new in the abstract seems to have been lost and we have no particular encouragement from our government and from our people to invent something new. I make a strong plea for the encouragement of aeronautical technology in a pure sense to understand more about what we are doing and to allow this understanding to create new ideas which we can bring to the surface and develop without hitching them to a PROJECT or a BUZZWORD or a SLOGAN.

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THE FUTURE OF AVIATION

SUMMARY OF PAPER PRESENTED
 BY JOHN F. LEYDEN, PRESIDENT
 PROFESSIONAL AIR TRAFFIC CONTROLLERS ORGANIZATION

Though the consensus of the aviation community believes that the continued automation of air traffic control will greatly reduce the need for air traffic controllers in the future, PATCO does not agree. Since we believe that controllers will be needed, this paper addresses the issues facing the controller workforce in the future.

Specifically, we believe that controller training must be upgraded and broadened to keep up with the challenges of new technological advances. It is imperative that human factor studies begin in the field of air traffic control so as to forestall and predict the possibility of human error. Controller compensation, responsibility, and exposure to the job should be investigated if we are to extend the work life of the air traffic controller. Finally, PATCO believes that the air traffic control system should be reorganized into a quasi-public corporation to best serve the needs of the nation and the aviation community.



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BIOGRAPHY

John F. Leyden

John F. Leyden, National President, born September 20, 1934, is married and has two children. Mr. Leyden was elected to current position originally in 1970 for a one year term of office; reelected in 1971 for a three year term and unanimously elected in 1974 for an additional three year term. Entered FAA as a controller in 1958 at New York Center. Received the "Federal Employee of the Year" in 1968, and served as PATCO Local President at New York Center prior to his election as National President. Mr. Leyden also serves as Chairman of the Executive Board; serves as a member of the Executive Board of Airline Passengers Association; serves as a member of the Board for Aviation Safety Institute; U. S. Representative to the Civil Aviation Section of the International Transportation Federation; and PATCO delegate to the AFL-CIO. Mr. Leyden also holds his private pilots license.



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A PAPER SUBMITTED TO THE SUBCOMMITTEE ON
 AVIATION AND TRANSPORTATION RESEARCH AND DEVELOPMENT
 OF THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY
 BY JOHN F. LEYDEN, PRESIDENT
 PROFESSIONAL AIR TRAFFIC CONTROLLERS ORGANIZATION
 ON MAY 24, 1976

It would seem, from scanning the FAA's plans for the future of aviation, that the major changes to come will be in the field of air traffic control. Moreover, after a closer examination of the proposed hard and software developments to be included in the Upgraded Third and Fourth generations of the air traffic control system, one may note that a by-product of this further automation, as envisioned by the Agency, is the almost complete elimination of the air traffic controller. If the Agency planners are correct in their forecasting, the new technology, like data-link, positive control, and metering and spacing, will result in the controller as manager/technician, watching the machines, monitoring the systems, supplying that, by-then, marginally needed human element in greatly reduced numbers. In fact, Administrator McLucas has said that future air traffic controllers will be "system managers".

While this picture admittedly appears bleak to PATCO, we are neither impressed nor convinced. We are reminded of the Agency's prognostications made through the late '60s and early '70s concerning the present Third Generation automated air traffic control system. ARTs and NAS Stage A were also sold to Congress and the public on the basis of removing high-cost manpower, the controller, from the system, and replacing it with a more cost-efficient substitute, the machine. The truth of the matter is that there are more air traffic controllers in the system today, almost two years after the implementation of ARTs and Radar Data Processing, than there were before. While the Agency continues to maintain that the automated equipment effects increased controller productivity, not only has this not been proven, but controllers, while considering the equipment an asset, argue that the new systems actually add to their workload due to the additional time and effort spent typing in data, and the complex operation of these sophisticated systems. If one equates increased safety with productivity, then we would agree that the automated systems have made controllers more productive due to the visual presentation of necessary data. But automation has in no way allowed the controller to work more airplanes or allowed the system to operate with less controllers.

For these reasons, I believe that the future air traffic control system will continue to depend on ground based personnel air traffic controllers, to provide the unique and varied services which machines cannot. Proceeding from this postulate, and recognizing that the aviation industry, which generally accepts the FAA's version of the future, will neglect to consider the needs of the future air traffic controller, the remainder of this paper will be concerned with the upgrading of the human element in air traffic control.

TRAINING

In the past, air traffic controllers training has been less than satisfactory. While the automated equipment has been in use in the field for 2 years, the Academy at Oklahoma City is still using broad band radar simulators to train students. Automated simulators are not expected for delivery for at least another 18 months to 2 years. Moreover, it has only been in the last few months that the course materials have been overhauled to include automated equipment operation. Thus, almost all training for the currently used technology will take place in the field on live traffic.

This is but one example of the "bare-minimum" attitude that has surrounded controller training in the past. The current process of 16 weeks "basic" training at the Academy, with the majority of training done on the field, may be inexpensive, but it is no substitute for a longer and more substantial curriculum which would include subjects on the various aspects of aviation in which controllers must be knowledgeable today. Besides the fact that ATC is more sophisticated than ever before and that the controller is being called on to provide ever-increasing services, it would be wise to recognize that the controller is an integral part of aviation and should be adequately trained for his place in the field.

One idea, whose time will come, is of a national aviation university where research, training, and labs could be brought together to encourage a breeding and testing ground for ideas, equipment, procedures, etc. The curriculum would parallel a four year college so that an entrant who washes out of ATC, for example, could merely transfer his major with no loss of precious time and money. This type institution would best produce individuals possessing the multi-faceted knowledge future aviation will demand and will be most flexible to radical changes in technology.

We also support the idea of mandatory pilot training for controllers. The Familiarization Flight Training program is a great asset in this respect, but it is obviously not the best or final solution to the education of controllers in pilot problems. We also realize that the cost of such a project may be prohibitive.

HUMAN FACTORS

Since most aviation forecasters believe the controller will be, if not totally extinct, greatly altered in responsibility and diminished in number, there is very little interest in the state of his mental and physical health, the causes of and solutions to his problems, or how these occupational health problems relate to air safety. Other than medical stress studies, human factors in air traffic control, the relationship between the man and the machine and the environment, is an almost uncharted area. Are there perceptual problems with different colored scopes? Are there controllers becoming too dependent on automated equipment? These and other questions have been barely asked, let alone satisfactorily answered. I believe this area to be of prime importance to the future safety of aviation and very worthy of intensive research.

COMPENSATION

That the job of air traffic controller is one of great mental strain, physical punishment and stark responsibility is a truism accepted by one and all. Hopefully, the controller will be better rewarded in the future for his trials. While the average journeyman controller working the standard 160 hours a month makes approximately \$22,000 per year, the average airline pilot working less than 80 hours a month makes approximately \$40,000 per year, almost double. While mandatory retirement for controllers, which PATCO strongly supported and which almost no one reaches, is age 56, the mandatory age for pilots is 65, and some isolated pilot groups are seeking to extend this limit to a later date. While the controller's closest comparative, the pilot, is responsible for one aircraft, the controller is responsible for any number, and the extent of that responsibility is growing from accident to accident.

While I well understand that the pilot directly puts his life on the line and thus deserves his pay, it should also be recognized that while a controller who has been involved in an accident survives, it is a bare survival. Nervous breakdowns are the norm and suicides are not unheard of. No controller who has been even remotely connected with a mid-air collision has ever been able to normally function as a journeyman controller again. Even if he serves his stint without an incident, he will retire early; a victim of ulcers, colitis or high blood pressure in the prime of his life.

Since I believe that controllers will be needed in the future ATC system, I also believe that a long, hard look should be directed at their compensation and its relationship to their responsibilities.

A corollary to this issue is that of time on the job. Most foreign nations have recognized that subjecting men to the stressful rigors of air traffic control is neither healthy for the man nor safe for the flying public. The majority of foreign controllers, who work with less traffic, less complexity, and thus less stress, also work a less than 40 hour week. This was recommended for American controllers by the Blue Ribbon panel on ATC headed by Dr. Corson in 1970, but has

never been implemented here because of the controller's federal employee status and because of the cost considerations. Though controllers are federal employees, it is absurd to lump them in with office personnel for the traditional forty hour week as the pressure is hardly comparable. As for the cost factor, maintaining a larger ATC workforce is a cheap price to pay for healthy employees with a longer work life and a safer system.

Another procedure which would relieve the controller's tension and allow him a longer working life would be the right to freely transfer from high pressure facilities to lower activity facilities without a resultant loss of pay grade. A man can only last so long at O'Hare, Kennedy and other busy facilities without burning out. This procedure would enable the system to retain the man's experience and expertise at a lower density facility and thus save on the high cost of training the employee's replacement.

In short, I believe that controllers workweek must be shortened to save wear and tear on controllers and to protect against over-extending the ability to safely handle aircraft on a daily basis.

AIR TRAFFIC CONTROL ORGANIZATION

The history of aviation safety in this nation has generally been one of reaction; reaction to accidents, reaction to public outcry and reaction to congressional pressure. Moreover, the response, whether it be technical or procedural, has usually already been in existence, ready to be implemented at the time it was needed. Much of the blame must be directed at the manner in which the air traffic control system is organized in this country. The FAA, being a sub-agency, has only secondary influence and muscle and is sluggish as a result. The DOT has politically and administratively interfered in aviation in the past and there is no respite in sight.

Because of these factors, in 1974 PATCO commissioned an independent consulting firm to conduct a study of possible ways and means to improve the ATC system's organizational structuring.

In brief terms, this study points out that the Air Traffic Control System, including its various supporting services, comprises a substantial part of the Federal Aviation Administration's personnel. Also that a substantial part of its budget goes for equipment, development, maintenance and operation of the ATC System. Thus, the study emphasizes the need to provide an organizational structure which most effectively will promote the highest level of efficiency in the future functioning of the ATC system.

To achieve this broad objective, the study calls for the legislative creation of a new organization. This would be an independent quasi-government corporation completely outside of the Federal Aviation Administration and the Department of Transportation, reporting directly to Congress. It would be governed by a Board of Directors representative of all sectors involved in aviation, and

would function along the lines of the best private industry concepts, completely outside of politics. The Corporation would receive its funding, equally divided, from general revenues and from user tax revenues. This study has been translated into legislation in the form of H.R. 12165 introduced by Representative Roncalio.

We recognize that the reorganization will take a number of years to accomplish. Until that time, PATCO recommends that the FAA be completely separated from the DOT. The Administrator of this independent agency should have cabinet level status. This access to the President is vital because of the importance of aviation to the nation as an industry and as a primary form of transportation. The Administrator's term of office must exceed four years, similiar to the term of the Comptroller General, to insulate the Agency from the changing currents of partisan politics. Legislation on this subject has also been introduced by Senator Goldwater in the Senate, S2434, and Congressman Goldwater in the House, H.R. 9930.

In conclusion, it is PATCO's belief that air traffic controllers, despite the increasing automation of the ATC system, will be needed in numbers comparable to the contemporary workforce. Though error-free equipment may someday be a technical reality, the unique talents which neccessitate man's inclusion in the system also force upon us the reality of human error. If we concentrate some of our future efforts on the human factor in aviation, we will assuredly be eliminating problems in the long run.

"Two Priorities in Aeronautical Research and Development"

Hans Mark, Director

NASA-Ames Research Center

In the last few years, a great many arguments have been presented which support national investments in research and development in aeronautics. Some of these are more valid than others and a complete evaluation of the reasons for performing aeronautical research and development is beyond the scope of this particular statement. I will not be comprehensive, but I do want to be very specific on two issues related to new aeronautical developments. One has to do with a major growth area in technology, and the other with our image as a major nation in the World.

It is my considered opinion that the major growth area in aeronautics in the next two decades will be in the field of Vertical Take-Off and Landing aircraft. There are, in my view, two reasons why this is so. One is that VTOL Aircraft will be absolutely necessary if our Navy is to continue to be in a position to maintain control over those sea lanes necessary for our trade. For this purpose, the supercarriers and the strike forces we have developed are probably not well suited, and what is needed is a smaller, more flexible operational capability. What we desperately need are high performance Verticle Take-Off and Landing Aircraft that can operate from normal ships. This "sea control" mission is so vital that it is bound to lead to new technical developments in the coming years. The second mission for which Verticle Take-Off and Landing Aircraft are vitally necessary is the one dealing with Army Mobility. In any foreseeable conflict, the United States will be outnumbered. Because victory in battle requires concentration of forces, this means we must have higher mobility than our advesaries or we will not be able to achieve concentration of force in a great many situtations. The only way such rapid mobility can be achieved is by the use of aircraft, and if these aircraft are to operate in arbitrarily located theaters of war, they must be Vertical Take-Off and Landing Vehicles. Helicopters have served quite adequately for this particular mission and they will undoubtedly be improved in future versions. However, it is probably desirable to have genuine Vertical Take-Off and Landing Aircraft which can fly much faster than helicopters and do not have the serious vulnerability problems that helicopters have exhibited. The mobility mission probably will in the end require vehicles such as the Tilt Rotor Aircraft or perhaps even a Lift-Cruise Fan Vehicle. The Army Mobility Mission is as important as the Naval one outlined previously and will also be a major source of impetus for aeronautical research and development.

- 2 -

The second priority I would like to discuss deals with the question of foreign sales of aircraft products. It has been argued many times that the foreign sales of our aeronautical products is an important factor in maintaining a positive balance of trade for our nation. While this argument is undoubtedly true, it is not unique. People who would like to develop other areas of technology can argue that in terms of foreign trade, agricultural exports, the export of nuclear reactors and nuclear materials, and the export of computers, could serve the economic purpose equally as well as the export of aeronautical products. This point is essentially correct, but I believe there is another argument that makes the preference of developing a strong foreign trade market for aeronautics when compared to other hardgoods quite obvious. This has to do with our prestige as a major nation. The point is that in contrast to agricultural products, nuclear reactors, computers, etc., aeronautical products tend to be highly visible to the public. I believe it is extremely important to our national status in the World that 85% of all commercial aircraft in the World today are of U. S. origin. This is something that people know and there is no way the fact can be hidden by governments that do not want their people to know it. I believe it is the obvious and high public visibility of aeronautical products that make the argument for developing airplanes for export a compelling one.

I believe that the two points I have outlined are the important justifications for performing research and development in aeronautics in a vigorous way. My hope is that our nation will continue to follow the tradition set at Kitty Hawk 73 years ago, and retain the leadership we have in this most important human endeavor.

Dr. Richard R. Nelson
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THE SUPPORT AND CONTROL OF THE CREATION OF NEW TECHNOLOGY:
 Lessons from the Supersonic Transport and the Breeder Reactor Programs*

Over the history of this republic, public debate regarding ways to organize, control, and fund research and development has focused on a wide variety of issues. The outcomes of the debates have been variegated. It is hard to characterize the full range of policy issues that has been considered; it is impossible to describe in any simple way the way things are. I believe strongly that while to some extent the variegation reflects a tangled confusion, in fact different issues and different sectors require different answers. Sweeping general answers regarding what the role of government should be are not likely to be useful. Public Policy toward R & D in agriculture, toward automobile manufacturing, and toward aviation certainly should be different one from another.

However, there are some issues that transcend particular sectors. Over the last decade much of discussion regarding public policy toward R & D for civil aviation has been concerned with the issue of whether public funds should be provided specifically for the design and development of equipment to be produced by private firms and sold in a basically private market. This particular question has a generality that goes beyond the aviation case. Similar programs have been debated, and implemented, in the field of atomic energy. Some advocates of a more active civilian research and development policy clearly believe that this is an attractive general strategy. I believe strongly that it is not. Since the issue, while especially germane to the discussion about policy regarding aviation, also has a wider significance, I will pair my discussion of the issues involved in the Supersonic Transport Program, with a discussion of the Liquid Metal Fast Breeder Reactor (LMFBR) Program. I do not think that we have learned enough in the debates about these programs, and the actual experience with these programs, as we should.

*This essay is basically Chapter 7 of my manuscript The Moon and the Ghetto--An Appreciation of the Unbalanced Performance of the American Political Economy.

The SST program ultimately was defeated, or at least scotched, but on the basis of argument that did not face squarely the general issues involved; thus there continues to be great pressure for government subsidy for R and D on new commercial aircraft.⁶⁵ The breeder reactor programs of the Atomic Energy Commission have proceeded with only a few murmurs regarding the strategy and rationale of the 1960's. With the energy crunch of the early 1970's, the AEC's programs have adopted both a broadened strategy and a more adequate rationale, but this has gone largely unnoticed outside the ranks of the professional AEC watchers. There is good reason to believe that, in the future, we shall see a growing flow of proposals for federal R and D programs modeled similarly to the two cases considered in this chapter. They are natural proposals by technologists.

⁶⁵ For a discussion see G.-Eads, "U. S. Government Support for Civilian Technology: Economic Theory versus Political Practice," Research Policy 3 (1974).

Second, a disturbing aspect of these two cases is that the pre-SST and pre-LMFBR programs in support of aviation and reactor technologies might well serve as an appropriate general model for the kind of subsidy and organizational independence for research and development, to be adopted in a significantly broadened arena of our political economy. The two cases under study suggest that appropriate government policy in research and development support maybe inherently unstable. Therefore, understanding of the forces that generated the programs in question would seem particularly important.

The New Departure: Federal Subsidy for Development of New Products for Production Sale by Private Industry to the General Public

While economists tend to argue that the market should be the dominant mechanism for governing R and D, in fact the role of public finance of R and D is very considerable. In 1972, of a total R and D spending of roughly twenty-eight billion dollars, approximately sixteen billion was federal funds. The purposes of the public R and D programs were numerous and diverse, but for the most part can be placed in two categories.⁶⁶ The first is the development of new technology for the public sector. The dominant programs here, of course, are defense related, but the government also undertakes or supports R and D to improve the ability of public agencies to protect the public health, guard against dangerous drugs and medicines, support construction of public facilities like airports and roads, enhance educational practice, deter crime, and so forth. In all of these cases the government is charged with performing a parti-

⁶⁶For a more detailed discussion, see Richard R. Nelson, M. J. Peck, and E. D. Kalachek, Technology, Economic Growth, and Public Policy, Washington, D. C.: The Brookings Institution, 1967, Chapter 8.

cular function, and the R and D is undertaken to permit it to perform more efficiently. But not all publicly funded R and D is directed towards public sector wants. A good portion is aimed to advance basic knowledge, or applied knowledge of widespread interest and use, or which supports particular important technologies but is not directly tied to particular marketed products. Here the NSF is the prime example of basic science support and the NIH perhaps the clearest cut example of a government agency in support of research underlying a broad technology (medicine). Another important example is long standing public subsidy of agricultural research done at federal and state experimentation stations. In the early 1960's NASA was a dramatic new departure in government sponsorship of a scientific and technological research both for the intrinsic interest of the adventure and because of the belief that diffuse and widespread benefits would be an important by-product.

Governmental spending for both of these purposes has traditions that go back far in American history. The constitutional responsibility for setting and maintaining standards for weights and measures soon led to a small research effort in the treasury department. The army arsenals performed R and D on a variety of weapons. Governmental support of research relevant to agriculture goes back well before the Civil War.

But, as the examples indicate, while the federal government often has supported research and development relevant to private sector activity, by and large, it has steered shy of supporting or undertaking research and development on a particular product or service whose normal channel of distribution would be through the market. (There are exceptions, for example, public funds have developed certain new seed varie-

ties, and pharmaceuticals, that then were produced and sold by private firms.) Rather, governmental R and D support has aimed to lay the basis for subsequent private development efforts, not to pre-empt those efforts.

The pre-1960's public support of research relevant to civil aviation fits this pattern almost exactly. In 1915 the National Advisory Committee on Aeronautics (NACA) was created to spur the development of American aviation. During its heyday, during the 1920's and 1930's, NACA pioneered in the development and operation of R and D facilities for general use (wind tunnels, for example) and information collection and dissemination. It supported the development of relevant theory and it undertook research on aircraft streamlining, design of engine parts, properties of fuels, and structural aspects of aircraft design. It built and tested a variety of experimental hardware. But NACA did not directly support or direct the development of particular commercial aircrafts. Indeed, the idea that such a role would be assumed by the federal government was explicitly rejected in the late 1940's when Congress refused to approve bills that would have appropriated federal funds to finance the construction of a jet transport prototype.⁶⁷

Until the early 1960's the programs of the Atomic Energy Commission (AEC) in support of civilian power reactors were similar in spirit to NACA support of aircraft technology.⁶⁸ The amended AEC act of 1954 esta-

⁶⁷ e.g., see the editorial "Costs and Jets," American Aviation (June 1, 1948), 1; and "U.S. Airlines to Buy British?" Aviation Week (August 29, 1949), 31, 32.

⁶⁸ For a discussion, see Phillip Mullenback, Civilian Nuclear Power: Economic Issues and Policy Formation, (New York: Twentieth Century Fund, 1963).

blished a more or less explicit division of responsibility between the AEC and private enterprise, with governments role limited to supportive research, the building of experimental reactors, the operation of facilities for testing, information dissemination, and so on. Private enterprise clearly was left the job of deciding and financing the particular technologies to bring into practice.

During the late 1950's and throughout the 1960's the AEC gradually increased the extent of its involvement in the development of civilian nuclear power, both in terms of subsidy and of detailed planning. By the mid 1960's the AEC was committed to a schedule of bringing to operational level a particular breeder reactor design - the LMFBR. Similarly, during this period the federal program in support of aircraft technology evolved from a traditional NACA type of effort to one of planning and financing the design and development of a particular aircraft, a supersonic transport. These represented major new departures in the government role in research and development in these areas. It is important to assess the factors that triggered these new departures.

In the breeder reactor case, according to Mullenback,⁶⁹ the equipment suppliers cannot be counted among the early enthusiasts for the growing federal push for atomic reactors, much less for the commitment to the LMFBR. Neither can the utilities, indeed, the private utilities tended to resist the building of governmental reactors on a sizeable scale, fearing that this might strengthen the tendency for nuclear power to go public. While there was less resistance on the part of the utili-

⁶⁹loc. cit.

ties to government subsidy of private construction and ownership of large experimental plants, in the early days the spirit seems to have been "if you insist that we build, you will have to share the costs" and not that of active advocacy. Of course, as the equipment suppliers gradually invested in their nuclear design and production capabilities they have grown increasingly enthusiastic about governmental programs that subsidize the procurement of nuclear power. But there was, and is, skepticism within all aspects of the electrical power industry regarding the commitment to the LMFBR.

The early thrust appears to have come largely from within the AEC and the Joint Committee on Atomic Energy. The major speeches of advocacy during the late 1950's and 1960's were by Commissioners and Congressmen; these were the active forces behind the gradual escalation of subsidy from assistance in studying the technology (in the mid 1950's) to paying a share of the capital costs and subsidizing reactor design costs (1960) to the present commitment of the AEC to the building and monitoring of the full panoply of equipment needed for a commercial LMFBR.

Similarly, the SST program seems to have been more the result of pushing from within the government than pressure from the outside.⁷⁰ The program appears to have bubbled up as a result of a coalition between NACA (by then NASA) people who had been researching aspects of supersonic flight in the traditional NACA context, and people at the Federal Aviation Administration (FAA). The early attitude of the airlines

⁷⁰ For a good review, see "Federal Steps to Date in SST Development," Congressional Digest (December 1970), 292, 293.

- 101 -

appears to have been that an SST was inevitable, but support for governmental subsidy of development was, at best, guarded. The manufacturers, naturally, were willing to proceed with the development of an SST under governmental funds, but the idea does not seem to have been theirs. In the early stages of the SST program it was not argued that federal funding would play the dominant role, but rather would have leverage on private funds. As with atomic energy, as the 1960's progressed, the extent of governmental subsidy escalated. The key events seems to have been the demise of the B70, the British-French agreement to proceed with the Concord, and the growing awareness on the part of SST advocates that the manufacturers would not proceed unless the subsidy was increased substantially. The governmental commitment grew from a twelve million dollar feasibility study in 1961, to (early 1960's) cost sharing of up to fifty percent of development cost through prototypes, to (late 1960's) ninety percent cost coverage by the government and finally to a commitment to carry the development through the post prototype stages which was implicit just before the program's demise.

The Inadequacy of the Arguments, and the Danger of the Strategy

There is no rationale for federal support of research and development that sharply delineates the scope of federal action - that enables clear cut articulation not only of why it is appropriate to undertake certain programs, but also why other programs should not be undertaken. While at first glance, the case for federal defense research and development spending appears to rest simply on the federal responsibility for national security, that a more subtle argument is required becomes

apparent when it is asked why Federal procurement would not provide adequate incentive for private R and D. The Federal Government is the world's biggest purchaser of typewriters, but does no R & D on them. The extent to which public R & D backs up public procurement differs greatly from area to area in ways that are not easy to rationalize. The issue of public R & D support in sectors where the goods and services are produced and procured largely by private parties is even muddier. Such support has been rationalized on the basis of arguments that there are general externalities from research and development, arguments that certain sectors (like agriculture) are structurally unsuited for private research and development, and in some cases a "national interest" in the product of the industry or in the industry itself has been articulated. The aviation and atomic energy cases have involved all of these rationales. But the question always can be raised, why subsidies for one kind of R & D or for a certain industry, but not for others.

In the aviation and nuclear power areas the division of responsibility for funding, and governance, was significantly better articulated than in other areas, prior to the SST and LMFBR departures. Public funds and a relatively separable R & D governance was provided for support of the expansion of the knowledge base for technological advance, to support and guide the exploration and testing of new technological regimes, to facilitate flow of knowledge to the producer, etc. The producers, feeling the market and assessing the value of new and old technologies, were to make the ultimate decision for development of particular designs. While final product development

tends to be the most expensive part of the research and development process, it also is the area where returns are most appropriable, and where market judgment is most appropriate.

The SST and LMFBR programs stemmed in effect, from a discontent of the technologists whose focus was on the creation of new options, with this division of labor and responsibility. The technologists looked ahead and saw that certain technologies would, in all likelihood, play a significant economic role in the future. These technologies were, in a sense, inevitable. Yet the private companies who had legitimate responsibility were making development commitments to particular technologies were not moving rapidly on these new options. The response of the technologists was to argue for governmental funds to do what they thought private firms ought to be doing but were not.

It was not argued that the technologies in these sectors were stagnating under the existing regime, or that some urgent national goal compelled acceleration. In aviation, technological progress had been extremely rapid, successive generations of new aircraft had made travel vastly faster and more comfortable, and prices of air travel (even not counting the great improvements in quality) had fallen relative to average prices. Indeed, at least one recent study concluded that the development of new aircraft perhaps has proceeded at too fast a rate, with CAB rate control authority precluding effective price competition by older planes to counter the speed advantages of the new, and thus providing an artificially profitable market for new high performance aircraft.⁷¹

⁷¹William A. Jordon, Airline Regulation in America: Effects and Imperfections (Baltimore: John Hopkins Press, 1971), esp. Chapter 3, "Rivalry Through Service Quality."

In view of the current alarm about energy, it is difficult to think back a decade. But at the time the LMFBR program began to take shape, there was no perception of crisis, or even of impending hard times regarding the price and availability of conventional fuel, which might make early achievement of a breeder a high return social policy. Fuel prices had been falling, not rising, in large part because the long run rate of productivity growth/ of electric power was ^{in the production} more than three times the national average. In their monumental study published in 1960 and available at the time of the LMFBR decision, Schurr and Netchert projected that coal reserves were ample in quantity and time to meet the demands at least to the end of the century without rising costs. They thought petroleum reserves were more problematical, but for the purposes of generation of electricity, they argued that coal could be substituted for petroleum without difficulty.⁷² The 1965 study of Energy R and D and National Progress, which was undertaken with the express purpose of identifying sources of concern, reached the conclusion that significant shortages of conventional fuels, or sharply rising costs of extraction, were not likely in this century.⁷³ With the wonderful vision of hindsight we now can see that these studies were overly optimistic. However, the advocates of the LMFBR crash program did not know then what we know now, nor did they argue effectively against the forecasts available at that time.

⁷² Sam Schurr and Bruce Netchert, Energy in the American Economy (Baltimore: John Hopkins Press, 1960).

⁷³ Energy R and D and National Progress, (Washington, D. C.: Government Printing Office, 1965).

- 105 -

What, then, were the arguments for the programs? The first line of argument was that large financial requirements and a long lead time, combined with uncertainty about returns and cost, might be deterring private firms from taking actions with a high expected rate of return. This position could not stand scrutiny for two reasons. First, in a number of cases private firms had raised funds on their own that were comparable to those involved in the projects under consideration here. For example, IBM is reported to have risked five billion dollars in the early 1960's to develop the system 360 family of computers.⁷⁴ Second, and more important, the expected rates of return on the projects were not high. Even cost benefit studies done by program advocates showed a rate of return in the SST, and on the LMFBR, that was low compared with typical private investment projects, under what many outsiders regarded as rigged assumptions.⁷⁵ That the expected rate of return was quite low was known to those who argued for the program on grounds of large capital expense requirements. Were this not believed both in the government and in industry, much more consideration would have been given to governmental loans and risk sharing, rather than one form or another of subsidy.

The second line of argument was that, in these cases, the social rate of return exceeded the private rate. However, as suggested above,

⁷⁴T. A. Wise, "IBM's \$5,000,000,000 Gamble," Fortune, (September 1966), 118.

⁷⁵For a review and critique of these studies, see Leonard Merewitz and Stephen H. Sosnick, The Budget's New Clothes: A Critique of Planning-Programming-Budgeting and Benefit-Cost Analysis, (Chicago: Markham, 1971). See also "Report of SST Ad Hoc Review Committee, Economic Subcommittee," reprinted in House Appropriations Committee, Hearings: Department of Transportation and Related Agencies Appropriations for 1970, (91st Congress, 1st Session), pt. 3, "Civil Supersonic Aircraft Development," pp. 321-324.

a case for some spill-over benefit can be made for virtually any technology and for almost any research and development project. The case for having public funds concentrated on basic and exploratory research and development is that these have a larger share of externalities than does final product development. What then were the "strong externalities" arguments for putting public funds in to final product development in these two cases?

Essentially the argument was that it is better for society to have a good thing earlier rather than later. In the cases of both atomic energy and the supersonic transport, it was apparent that the technologies would be valuable to have around, if they achieved anything close to their potential, and if their environmental problems could be resolved. In the cost benefit studies of the breeder reactor program, a considerable amount was made of the fact that, given the large and rapidly growing market for electric power, hastening the day that we have breeder reactors that are superior economically to existing technologies, would enable us to start our benefit flow earlier, and enhance the total benefits we would reap. In the SST studies, the same kind of argument was employed, and a supplementary point argued. It was claimed that failure to exploit the technology embodied in the supersonic transport at the earliest possible moment would mean a loss of technological leadership which in turn would mean an irreversable loss of world commercial position. The advent of the British-French program to develop the Concord of course accentuated these arguments.

On reflection these kinds of "externalities" argument really aren't very persuasive, and certainly don't point to the proposed programs.

In the first place, in these cases (and more generally) it is hard to see a "social benefit" in hastening, that significantly exceeds benefits that would appear to business firms as profit opportunities. Interest rates put a premium on earlier rather than later returns, and often it is argued that private incentives focus too much, not too little, attention on early benefits. If the argument were changed to posit that the private rate of time discount were too high to induce private funding on projects whose payoff will occur only with a long time lag, then the implications would seem to be support of an old style NACA or AEC policy of funding of experimental work, not a crash program. Nor does the "commercial leadership and export revenue argument point to social benefits as opposed to private benefits, and certainly not to R and D as an instrument for the achievement of such social purposes.

The basic reason why private investment funds were not flowing into an accelerated development program cannot be ascribed to "externalities" but rather to the high cost and innate inefficiencies involved in rushing a technology. Common sense, history, and detailed analysis all tell us that there is a time cost trade off.⁷⁶ Public subsidy can buy us time, but we pay for speed. The costs of hastened development must be weighed against the benefits of gaining an attractive technology sooner. While the cost benefit studies stressed the benefits of faster achievement, they either ignored or denied that we could achieve the same results more cheaply if we hurried less. But this was really the issue. Why were the costs and risks too great in these programs for private enterprise to bear? In good part because at the targeted rate

⁷⁶ For a discussion, see Frederick M. Scherer, "Government Research and Development Programs" in Robert Dorfman (ed.), *Measuring the Benefits of Government Expenditures* (Washington, D. C.: The Brookings Institution, 1965).

of development one could not proceed sequentially and in small bites, keeping options alive and not committing large funds to any one until the evidence in its favor was clear.

The organizational model behind the scenes of the LMFBR and SST proposals of course was that of the Manhattan project to develop the atomic bomb during World War II, project Apollo, and much of military research and development. The style involves a willingness to make large early bets on particular technological options and force these through, or engage in very high cost parallel efforts. The strategy can buy rapid technical progress, but at very high cost and enormous waste.

One of the more striking aspects of the history of technological advance in most American industries is the diversity of sources. New products, processes, inputs and equipment for an industry have come from firms in the industry, suppliers, purchasers, new entrance to the industry and outside individual inventors. The process certainly has not been orderly and planned, but one has the impression that had one tried to impose order and central plan the results would have been worse. Many developments that earlier seemed to be very promising did not pan out. Many important breakthroughs were relatively unexpected and were not supported by the experts in the field. While detailed case histories are not plentiful, one has the impression that in most of the technically progressive industries, like chemicals and electronics, most of the bad bets were rather quickly abandoned, particularly if someone else was coming up with a better solution, and good new ideas

generally had a variety of paths to get their case heard.⁷⁷

Military research and development programs since the mid 50's the civil reactor programs, and the supersonic transport experience, are in sad contrast. In all of these areas the early batting average has been dismal. However, there has been a proclivity to stick with the game plan despite mounting evidence that it is not a good one, that appears only in exceptional cases in areas where research and development is more decentralized and competitive. The case of Convair's throwing good money after bad on the 880 development rightly is regarded as an abomination, and the fact that General Dynamics had learned its style in military R & D undoubtedly was a contributing factor. But this kind of thing is the rule, not the exception in military R & D. The B-58 and TFX were pushed all the way through development despite mounting unfavorable evidence. The B70 and Skybolt were halted short of procurement, but long after the signals were clear that they were bad ideas. Advocates of the SST and CMFBR implicitly denied the relevance of this experience. The heart of the programs was early commitment of governmental funds to a particular design.⁷⁸ In the supersonic transport case it is highly unlikely that Boeing would have persisted so long in

⁷⁸See the discussion in Burton Klein, Andrew Marshall, William Meckling, and Frederick M. Scherer in The Rate and Direction of Inventive Activity (Princeton, N. J.: Princeton University Press, 1962.)

⁷⁷ See, for example, the case studies in John Jewkes, David Sawers, and Richard Stillerman, The Sources of Invention (New York: St. Martin's Press, 1970); Merton J. Peck, Competition in the Aluminum Industry (Cambridge, Massachusetts: Harvard University Press, 1961); R. Miller and D. Sawers, The Technical Development of Modern Aviation, Routledge and Kegan Paul, 1968, and Nelson, Peck, and Kalachek.

- 110 -

pushing its swing wing SST design had the bulk of the funds been its own, and had it the ability to make that decision on its own. The result, of course, was a clear technological failure. Similarly, throughout the history of the AEC power reactor program there have been complaints that the AEC was persisting in R & D on a design long after evidence had accumulated that the route was not an attractive one, and also that the AEC has been very sticky about initiating work on new concepts. The LMFBR still is a very risky design, and it does not make much sense to place all of our chips in it. Only the overall expansion of energy R & D budgets in the early 1970's has gotten us off that hook.

The Problem of R and D Governance

While a strong case can be made against these programs viewed as social investment projects, the cost-benefit kind of analysis does not probe deeply enough. Perhaps the most basic reason why the two programs under consideration were unwise is that they failed to come to grips with the fact that R and D governance, and the governance of the provision of the goods and services with which R and D is connected, need close integration at the level of product or process development. The case for some autonomy of R and D governance is persuasive at the level of exploratory research and development - the kind of work NACA and the AEC used to stress. But autonomy at the product development level is foolish or downright dangerous.

To establish relative autonomy of product development decision in a sector where new products must meet a relatively rigorous market test is to court commercial disaster. That the United States has dominated

- 111 -

the commercial aircraft market in the postwar period is undeniable. Recent estimates reveal that over 80 percent of the worldly commercial airline fleet was built in this country.⁷⁹ Phillips' research makes it clear, however, that this dominant commercial position rests not only on the general technical virtuosity of U.S.-built commercial aircraft but also on the good record of the American manufacturers in deciding when to embody technological advances in commercial products.⁸⁰ This record undoubtedly has been aided by the fact that in each case, the decision to produce a commercial design has been made by a private company risking its own funds. There is no doubt, for example, that if Congress had been willing to appropriate the necessary funds in 1948, the U.S. and not the British could have been the first to introduce jet transports into commercial service. It is clear from a study of the designs then being proposed, however, that the early U.S. jet transports would have been no more viable commercially than were the Comet I and Comet II. And how much would it have aided the reputation of the American commercial aircraft industry had it, and not the British, been the one to discover the catastrophic effects on pressurized aircraft of metal fatigue?

⁷⁹ Statement of James M. Beggs, Undersecretary of Transportation, in Economic Analysis and Efficiency of Government, op. cit., p. 962.

⁸⁰ Almarin Phillips, Technological Change and the Market for Commercial Aircraft, Heath Lexington, 1973. This point is also stressed by Miller and Sawers, op. cit. They point out, for example, that the Comet I, with operating costs almost three times as great as the DC-6B, could make money only as long as only one carrier on a route was operating it. As soon as a second carrier offered Comet service, the first carrier's load factor would drop far below break-even level. This factor obviously limited the market for the Comet in spite of its substantial advantage in speed over piston aircraft.

In contrast to the U.S. experience, the record of the British aircraft industry in the postwar period has been dismal. The British government has been prepared to cover up to 50 percent of the costs of launching civil aircraft designs and to assure a base market for these designs by requiring the British flag carriers to purchase the resulting product, regardless of operating costs.⁸¹ As a result the British have rung up a string of technological successes that, by and large, have been commercial failures. Even the massive infusion of governmental aid has not served to maintain the health of the British aircraft industry, and, with few exceptions, the aircraft have generated nowhere near the hoped-for volume of export earnings.

When there is no powerful autonomous value setting mechanism, like a market or a public agency not strongly influenced by producer interests, the problems are even more serious. It is disturbing that there was not more vocal concern about the implications of a governmental stake in the supersonic transport, particularly given the explicit revenue sharing provisions of the program in its later stages.

⁸¹ Robert E. Baldwin, Nontariff Distortions of International Trade (Washington, D.C.: the Brookings Institute, 1970). This latter commitment alone was costing the British government an estimated \$80 million in subsidy to British European Airways in 1968.

Miller and Sawers, op. cit., list the total direct contributions (prototype and production support) by the British government for commercial aircraft jet engines and airframes between 1945 and 1965 (including the VC-10, Trident, and BAC-111 but excluding the Concorde) as 61 million pounds and 67 million pounds respectively. Total repayment to that time amounted to 13 million and 12 million pounds. No engine (of seven) and only one aircraft (of ten) had produced royalty payments to the government in excess of the government's contribution toward the development, even not allowing for interest.

Even without a financial stake, the government agencies, and the higher executives and congressmen who support a program, have a personal credibility stake in the success of the products and processes they push. It was relatively clear that the success of the supersonic transport program, measured along almost any dimension that had been talked about, would have depended highly on the fare structure allowed and encouraged by the CAB. The CAB could have gone a long way toward making the SST program a financial success by fighting for high fares (to cover the higher costs of the SST relative to the jumbo jets) and uniform fares (so that the lower cost technology would not be able to compete in the dimension where it was strongest). It is rather surprising that the producers of coal and oil, and of power generating equipment using conventional fuels, have not raised more noise than they have regarding the pressure being applied to the utilities by the Atomic Energy Commission to install nuclear rather than conventional power. While the evidence on the nature of thermopollution and nuclear waste problems is far from clear, and it well may be that nuclear power still looks good compared to conventional power in pollution and waste problems, we all should feel some discomfort that a strong governmental lobby has a stake in the issue. I do not want the reader to carry away the impression that the central problem of research and development policy is to contain the aggressive technologists. In many cases this is a problem. But at least as important is somehow to enhance the pace of advance of scientific understanding and technology regarding the large share

of human activity where progress has been lamentably small. Here the conservatism of the economist, who tends to see little need for some autonomy of research and development unshackled from the short run and myopic incentives affecting both business firm and government bureaucracy, is at least as much a danger as the often naive optimism of the research and development buff.

The disparities in rates of growth of productivity across our economic sectors have been enormous. To cite illustrative numbers, the percentage yearly increase in output per worker (1948-1966) was 5.6 in farming, 4.6 in mining, 2.9 in manufacturing, in contrast construction 2.0 percent, general services 1.2 percent.⁸² These broad sectoral categories themselves conceal great dispersion. Within the manufacturing sector productivity growth in chemicals was 6.0 percent a year, petroleum refining 5.5 percent, electrical equipment 4.1 percent, while down at the other end of the spectrum, productivity growth in apparel was 2.2 percent a year, in leather products 1.7 percent. By and large (and with a number of important exceptions) productivity growth in those industries that produced products or which employed products in an essential way in the delivery of services (like airlines) experienced productivity growth at a significantly faster rate than those sectors delivering personal services.

⁸²These figures are from John Kendrick, "Productivity Trends in the United States."

The consequences of this great imbalance in rates of technological progress across different sectors and activities have been profound. Empirical evidence strongly confirms the prediction of economic theory that prices of different industries should move with total factor productivity. The consequences of sharply differing rates of productivity growth have been significant changes in our relative price (and cost) structure. Thus we have experienced sharply rising relative costs and, sometimes, deteriorating quality in the slow productivity growth industries - housing, personal services, education, and a whole collection of governmentally provided services like garbage collection and street cleaning. Many of the complaints that people have about the way the American economy has evolved seem to relate to their distress caused by this unbalanced evolution of technology.

Perhaps nothing much can be done about it. But the dramatic success that has been achieved through government supported programs in several of our key sectors, suggests that we might want to give it a try. Much more attention ought to be given to our experience in agriculture than has been given up to now. Ironically, there is much to be learned from the old NACA experience and the earlier days of the Atomic Energy Commission. In all of these sectors we seemed to have achieved a highly efficacious mix of governance of R and D, with applied research and development being relatively closely linked to the market, and basic research and exploratory development being given a much looser reign, and separate support. It is highly unlikely that the exact form of the organizations adopted in our successful sectors can be carried over to the new areas.

Indeed it is not clear even what that would mean, since the structures differ significantly among themselves. But I propose that posing the problem in terms of the design of a semi-autonomous structure for certain kinds of R and D is a useful way to begin the search.

The cases discussed in this chapter, however, should warn as of a danger. Separate R and D organization seems to be infected with a camel's nose syndrome. Unless carefully monitored, it becomes a powerful lobbyist of new technology for its own sake. Controlling independent R and D organization may be as difficult as designing it. Certainly both tasks require a sophisticated awareness of the purposes, and the dangers, of R and D autonomy.

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RECOMMENDATIONS ON FAA

RESEARCH AND DEVELOPMENT PROGRAMS

February 20, 1976

1. Basic Deficiencies:

Over the years part of the difficulties which have caused uncertainties in the development of the Agency's research and development programs has been the failure to identify requirements in terms of the total aviation community--scheduled/non-scheduled air transportation, general aviation (FAA definition), and the military services. Initially (and for good reason due to the impact of the Grand Canyon, Nellis and Brunswick incidents) the principal emphasis was placed on air carrier requirements. The situation has changed, however, and the usage of the air space by general aviation in terms of hours represents a factor of 5 to 6 times as much as that of the air carriers (although obviously the passenger count is probably 2 to 1 in favor of air carriers); from the standpoint of numbers of operations, general aviation far outnumbers the carriers. The important point is that this change in relationship insofar as the usage of the air space is concerned must be reflected in a new look at the requirements, goals, objectives and programs, together with a more carefully analysis of the economic implications to the user community.

A. In the light of the foregoing, the FAA has failed to:

- determine requirements in a manner adequate to reflect the total needs of the user community
- establish specific goals (based on such requirements)
- identify objectives (based on the goals)
 - short term
 - long term
- delineate programs to achieve specific objectives

All too often the research and development activities appear to develop a "solution", but it is sometimes hard to identify the "problem".

B. There is an unfortunate and expensive overlapping of effort, and an uncoordinated duplication of programs within the government agencies, with inevitable excess cost to the taxpayer. Among the obvious departments involved are the DOT and the FAA, NASA, and NOAA, and looming over the horizon, the Environmental Protection Administration; undoubtedly, there are other agencies of government who can be found suspect in this regard.

- C. There has been all too little opportunity afforded the user community to provide inputs to the R&D planning process. The FAA is not altogether responsible for this situation, as some of the blame must rest with the users, but the fact remains that there has been all too little dialogue between the Agency and those it serves insofar as requirements and discussion of programs are concerned.
- D. There has been a failure to grapple with the economic implications to the users of many of the concepts which eventually become FAA R&D programs. Unquestionably, these concepts in many instances are exciting, but little or no attention is paid to the cost to the user that may be involved in terms of hardware and operational procedures.
- E. There is a failure to recognize the intermodal aspects of air transportation in all its forms--scheduled/non-scheduled air transportation, commuter/third level carriers and general aviation (as defined by FAA terminology). As an example, there is an obvious interface with surface modes in almost every aspect of air transportation, including mass transit potential with respect to the ingress/egress to and from the aviation facility (airport, STOLport, helipad, etc.).

2. Recommendation for Systems Approach:

In the light of the foregoing, there would appear to be several important steps which need be taken to rectify these deficiencies, and initiate a true systems approach to the overall research and development needs of the aviation community.

- A. The national transportation policy and the national air transportation policy must be finalized. Secretary Coleman has made a good start in this area, but the statement needs to be sharpened; there is no overall national air transportation policy. It would then be necessary to determine, in the light of these statements of national policy, the following:
 - requirements
 - goals
 - objectives
 - programs

This effort would address itself to the deficiencies identified in paragraph numbered 1.

- B. Establish a top level mechanism which ensures total coordination of inter-related programs of any and all agencies. This must be a meaningful effort with the twofold objective of eliminating once and for all the overlap, duplications, and "reinventing the wheel"; and (most importantly) the structuring of the combined effort, so as to ensure the assignment of areas of interest

- 3 -

to the agency(s) best qualified in terms of resources and personnel to achieve the objective(s). Integral to this effort must be an evaluation of the resources and personnel of the university community, with their extensive laboratories and qualified experts. Interdepartmental jealousies or ambitions should have no place in any such effort. It may well be that the most practical approach (to sort out these appropriate areas of interest) is to have it carried out under the direction of an impartial body such as the National Academy of Engineering, the National Academy of Sciences, or the National Science Foundation. As an objective, the end result should be an inter-agency committee at the highest level to whom appropriately staffed task forces in each area of interest should report.

- C. An effective procedure must be developed by which user inputs and constructive comments with respect to Agency programs can be channeled into the planning process. The suggestion has been made to develop a Notice for Proposed Research Program (NPRP) to be published in the Federal Register and on which comments are solicited in much the same manner as the NPRM. Admittedly, there are bureaucratic problems which might develop from such a procedure, but if care is taken in the development of the procedure, they could be minimal; at least user input would be assured.

3. Specific Recommendations in Program Areas:

In addition to the foregoing recommendations as to the basic systems approach to aviation R&D, there are some specific suggestions with respect to identifiable areas of interest:

- A. Air Traffic Control - The FAA should take a hard, objective look at the overall program to ensure that the end result provides safe and efficient use of the airspace, and that it be economically feasible for all users thereof. The objective must be a benefit/cost ratio greater than one. The distributive management concept (or airborne display) deserves careful and objective review, as one concept which might reduce the proliferation of a massive, costly ground environment, and our current, near-total reliance on management from the ground--a hardware- and labor-intensive approach we may not be able to afford in its ultimate form.
- B. Aircraft Design and Operating Characteristics - Stability and control, all-weather operations, and environmental impact of aircraft operations are all-important areas. This will require extensive analysis as to goals, objectives and programs, and will necessitate the important assignment of responsibility in accordance with Agency capability. Basically, NASA should be assigned those areas of research and, where appropriate, "proof of concept" compatible with its capabilities; FAA should be responsible for applied research, as well as test and development. In this area, the guidance and assistance of an impartial organization, as suggested in paragraph numbered 2C, would be invaluable to ensure proper allocation of responsibilities.

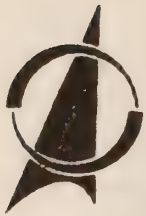
As an example, the development of a practical Wake Vortex Avoidance System--a critical problem permitting reduced aircraft separation--may well be concentrating too much effort in the detection area, without adequate attention to eliminating the problem at its source. The cost implications of a detection system are frightening.

The environmental area is critical, with first priority being assigned to noise; and right behind it the question of emissions. Again, a team approach is recommended, whereby FAA, NASA and EPA would be assigned their respective responsibilities by an impartial group (again, as set forth in paragraph numbered 2C). In this connection, the whole question of operating procedures in the noise problem area is an important one, and a joint FAA/NASA effort would be sound.

In similar fashion, it is important to approach the problem of STOL operations, particularly in the terminal area, in an intelligent manner so as to capitalize on the maximum potential of this new and improved vehicle; this would include the vehicle, its operating characteristics, and its integration into the overall system (including ATC).

- C. Navigation/Communications - There must be an emphasis on cost reduction--both capital and operational. The basic approach must be that the "Chevy" will do the job equally as well as the "gold-plated Cadillac"--a philosophy in large measure foreign to the FAA at this point in time. Another important area requiring attention is the problem of determining the accuracy of the navigation facilities; this must be performed by ground monitoring devices to an increasing extent, thereby eliminating to a far greater degree the expensive flight checking procedures, provided maximum accuracy and reliability are assured.
- D. Airports - Improvements in airport design in the interest of efficiency, and pavement research are important. In the area of general aviation, increased attention should be given to the development of a low-cost airport design--again, the "Chevy" versus the "Cadillac". To meet the requirements, a valuable lesson is to be learned from the Ohio State program. Admittedly, some criticism can be directed at the fact that some of these airports are "breaking up". It would seem wiser, however, to ascertain why they broke up rather than condemning the program because of this problem; perhaps some remedial recommendations can be developed. The basic concept is too valuable and important to downgrade it because of the NIH factor!
- E. Weather - There is an on-going need to improve forecasting techniques and reliability, the automatic reporting capability, and the dissemination of this information. It is recommended that there be a joint FAA/NOAA effort and that it be integrated as an important part of the FSS modernization effort.

- F. NAFEC - It is recommended that this establishment be retained as an invaluable, unique and irreplaceable resource for test and development. It must, however, be operated on an austere basis, and the replacement/expansion of facilities justified on the basis of realism and need; modifications should not be permitted merely for "window dressing".



PIASECKI AIRCRAFT
C O R P O R A T I O N

REPORT 99-X-17

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TITLE

INNOVATION BY SMALL BUSINESS IN THE
AEROSPACE INDUSTRY
NATIONAL TRANSPORTATION RESEARCH
& DEVELOPMENT POLICY REVIEW

PREPARED:

E. N. PIASECKI



INNOVATION BY SMALL BUSINESS
IN THE AEROSPACE INDUSTRY

TABLE OF CONTENTS

1. INTRODUCTION
2. SUMMARY
3. PROBLEMS OF SMALL BUSINESS IN INNOVATIVE TECHNOLOGY PROCUREMENT
 - 3.1 FINANCING PROPOSAL COSTS; NEW CAPITAL VS. INAD
 - 3.2 "NO REQUIREMENT" SYNDROME
 - 3.3 LOW CASH FLOW
 - 3.4 DEPRECIATION OF PATENTS
4. R & D PROCUREMENT PRACTICES NEGATIVE TO INNOVATION
 - 4.1 FRAGMENTATION OF INNOVATIVE CONCEPTS (LOSS OF IDENTITY)
 - 4.2 GOVERNMENT "MAKE-OR-BUY" POLICY
 - 4.3 GOVERNMENT EXPRESS NEEDS IN MISSION TERMS
5. FUTURE NEEDS AND OPPORTUNITIES
 - 5.1 THE NEED FOR VERTICAL LIFT AIRCRAFT
 - 5.1.1 MILITARY
 - 5.1.2 COMMERCIAL/INDUSTRIAL
 - 5.2 LAND USE AND OTHER CONSUMER DESIRES
 - 5.3 TRENDS IN FOREIGN VTOL R&D
6. CONCLUSIONS AND RECOMMENDATIONS
7. REFERENCES



PIASECKI AIRCRAFT
CORPORATION

PAGE

REPORT 99-X-11

ISLAND ROAD, INTERNATIONAL AIRPORT - PHILADELPHIA 42, PENNSYLVANIA

INTRODUCTION

This report presents the view of an innovator group who designed and developed one of the first U. S. helicopters in 1943. The success of this innovation created a large and successful company which employs thousands of people and brought hundreds of millions of dollars of sales per year.

This tremendous success built up the industry into larger units. The original company was sold to a larger aerospace company, and the original innovators formed a small company with the desire to continue innovation in vertical lift. However, the capital requirements that are now required to meet the growing voluminous government requirements and regulations before sales can be achieved, are not available. Hence, this small-business company must rely on the government for research and development funding; but these funds have been materially reduced and are erratic in availability. Further, it is forced to compete for these funds with large companies receiving government "IR&D" through their production overhead. Thus, the organization is prevented from achieving its innovative objectives.

Suggestions for the improvement of the government's role in the innovative area are offered, particularly as it affects the small company in a high-technology field.

It is hoped that proper government action will help the small company continue its historical role in technological innovation. If this sector is destroyed, the country will lose the benefit of alternate choices of innovation promoting progress. If it is saved and nourished, new industries can grow and yield huge economic and real social benefits to our nation.

2. SUMMARY

Our nation has great strength in the efficiency of our innovation process, the marketing of new products and the resulting growth of successful research ventures. One of the major sinews of this strength comes from the independent competitive nature of our civil research and development.

Yet in recent years innovative growth has been reduced in aerospace particularly in vertical lift. Our technological leadership is waning from lack of new capital and from the decreasing number of independent organizations seeking innovation.

This negative situation has come about for many reasons, including high taxes that do not leave sufficient surplus for reinvestment into innovative concept. Regulations on the sale and use of aircraft and operating procedures that favor fixed-wing transport aircraft add to the large financial investment required before income is received.

Competition is unbalanced by the government permitting the larger production Aerospace companies to charge their "Independent Research and Development", and proposal and bid preparation costs, to government contracts, whereas the innovative small company just starting must pay for such costs out of its capital. Unsolicited proposals created by innovators find additional hurdles as they are limited in dollar value (\$100,000), and by annual funding and budgeting requirements.

Many procurement practices exist negative to innovation, including the separation of the idea from the innovator, long time delays in "evaluation" of a new concept, doing the research work inside the government instead of through the proposer, splitting the idea into parts to dissociate the originator, and depreciation of the innovator's patent position. Finally, if the new concept runs counter to the existing "plan" it is rejected as having "no existing requirement", whereas other systems continue in their production.

Private capital cannot make the necessary investment risk with a small company. SBA and FDA funds are available for such ventures but are restricted in their use and amounts. DOD approaches the innovation with a time scale that does not match the subsistence requirements of the innovator. Foreign competition developments proceed with their (and sometimes our own) government's assistance. What happens to the innovative concept? In one case it waited 16 years for recognition and used up 12 years of its patent life. What does the innovator do? His fate will be a mark of discouragement to those who follow and deduce, "Why innovate if the carrot is but an illusion?"

2. SUMMARY (Cont'd)

Suggestions are offered for government action to improve the climate for small business attempts at innovation, including:

- 1) Guaranteed loans to small business repayable from the proceeds of innovative product development.
- 2) A portion of R & D contracts to be set aside for small business equal to the IR&D funds allowed by the government to be charged off to government contracts.
- 3) Increase the \$100,000. limit on unsolicited proposals to \$1 million.
- 4) Laws to limit government in-house work, in order to maximize the use of outside industry.
- 5) Laws to limit the use of "Non-Profit Think-Tanks" for evaluation and planning purposes (which is the job the government is supposed to do in-house). (Ref. 2)
- 6) Patent life to be extended to 25 years, or more.
- 7) No indemnification guarantees be issued by the government for patent infringement by its contractors.
- 8) Procurement requirements to be stated by functional performance and not in hardware terms, to permit greater use of innovation to assist in the solution of our national problems.



PIASECKI AIRCRAFT
CORPORATION

PAGE

REPORT 99-X-17

ISLAND ROAD, INTERNATIONAL AIRPORT - PHILADELPHIA 42, PENNSYLVANIA

3. PROBLEMS OF A SMALL BUSINESS IN INNOVATIVE TECHNOLOGY PROCUREMENT

The ability to get capital to finance proposal costs has become a serious problem for all, particularly small business, and is particularly destructive to small business in the government procurement of R&D.

If an innovative development is made by small business on its own investment, there is a high risk the innovation will not bear fruit because of the following government actions:

- (1) Delay, by declaring the innovation too advanced and not having an established government "requirement" for the item.
- (2) Fragmented into small R&D tasks assigned by the government technicians to new "Requests for Proposals" for other companies to work on.
- (3) Being taken over as an "in-house" "break-out" by the government laboratories as "their" project.
- (4) Given out to captive Academic Institutions for further "study."
- (5) Given out to captive "Think Tanks" to "assess, evaluate and study."
- (6) Awarding a study contract under \$100,000 with long review periods (years) in between awards so that small business cannot maintain its innovative activity.
- (7) Life of patent expires or is sufficiently shortened to minimize return to originator, thus eliminating the incentive for innovative investment since the larger companies will use the ideas without any return to the originator.

Following are more detail discussions of the above problems.



PIASECKI AIRCRAFT
CORPORATION

PAGE

REPORT 99-X-17

ISLAND ROAD, INTERNATIONAL AIRPORT - PHILADELPHIA 42, PENNSYLVANIA

3.1 FINANCING PROPOSAL COSTS

Requests for government funds for innovation must be placed into a written submittal to the government as an unsolicited proposal or as a response to a government Request for Proposal advertised in a daily government publication called the Commerce Business Daily. This is true whether the innovation has been physically demonstrated or whether it is patented, or whether it is just a concept described in words, drawings and calculations.

Unsolicited proposals have increased in complexity with growing technology, and with the broader government considerations necessary to review in the proposal, preparation costs have risen continuously and sharply.

Therefore, the small innovative company must invest its capital funds for the preparation of proposals, either an unsolicited proposal or in a response to a public request for proposal.

The large production company, already doing business with the Department of Defense, is permitted an overhead charge against its existing government contracts for purposes of preparing such proposals. In the larger companies this amounts to millions of dollars per year. Hence, the smaller, starting, company has little chance to penetrate against such expenditures, paid for by the government today.

"Independent" R&D projects are funded under DOD contracts as an "indirect" overhead charge. Thus, the production companies with the biggest production dollar flow can have the largest government financed R&D program, which in turn becomes their RFP response or unsolicited proposal.

Severe hardship and unfairness occurs when the small company, is starting up, not having production contracts, and must finance its proposals with its own capital, in order to compete with the "big boys", financed by the government.



PIASECKI AIRCRAFT
CORPORATION

PAGE

REPORT 99-X-17

ISLAND ROAD, INTERNATIONAL AIRPORT - PHILADELPHIA 42, PENNSYLVANIA

3.1 FINANCING PROPOSAL COSTS (Cont'd)

Yet the small companies have historically been major generators of new ideas and their application. Xerox, Polaroid, Vertol, IBM, Boeing, McDonnell-Douglas, started as one-man innovative companies.

The Small Business Agency has a policy carried out by DOD and others to "set-aside" a portion of the annual procurement funds which are offered to SBA companies. To date these set-aside funds have been primarily in manufacturing or overhaul work.

The annual IR&D plus B & P (Bid and Proposal Costs) are approximately 3.76% of the total contractor sales to DOD (Armed Forces Journal, March 1976). At a procurement level of \$39B this would allow \$1.35 billion for IR&D and B & P costs this year for the defense industry to use.

If a fair balance in R&D funding between big and small business is to be maintained, it is recommended that Small Business get a set aside in R&D funds equal to the IR&D funds permitted as allowable charges under government contracts with industry.

Similarly, the Economic Development Agency of the U. S. Dept. of Commerce and the Small Business Agency have, by practice, limited their grants, loans and loan guarantees to low dollar values (below \$500,000) and for limited purposes such as capital improvements, production equipment, tooling, etc., but have restrained funding for innovative development purposes.

Innovation research and development, model and prototype construction costs have escalated even more than standard costs and therefore, such fund size limits are not realistic, nor practical.

Government limits of the above funds to production items and capital equipment is discriminatory. These limitations should be removed, provided the product development objectives meet defined national needs.



3.2 "NO REQUIREMENT"

Notwithstanding all of the above problems in the procurement of innovative ideas from small business, the intense desire of the innovator to push forth his concept on the basis that it will bring him a large return, forces his interest and persistence in spite of all the above obstacles. How long this will continue is difficult to assess. It is said that hope springs eternal, but in this case the pocketbook must come along with the hope, and the size of the pocketbook necessary is growing in size.

However, in spite of all of these difficulties sometimes there emerges a considerably advanced innovative concept that goes through all of the above processes and comes out as a successfully demonstrated item. In this case, there is the final hurdle for the innovator to go over in the procurement side of the government agency. Procurement must ascertain what the requirements are for such innovative equipment. In most cases, the production side of the house is well connected to the established production sources and is concerned with production matters. Any "unplanned" innovation is viewed as upsetting the status quo of the procurement situation. Thus, the innovative idea is usually turned down as not required as a production item. Hence, we have our museums full of devices that, although successfully demonstrated, are still waiting for their day of application.

We have several such vehicles including:

Air Geep I - Ft. Eustis Army Transportation Museum
 Air Geep II - Ft. Eustis Army Transportation Museum
 Sea Bat Drone - Phila., Pa.
 Ring-Tail Compound Helicopter - Phila., Pa.

Others of similar programming:

Avro Saucer - Ft. Eustis, U.S. Army Transportation Museum
 AAFSS Cheyenne - U.S. Army
 STAMP I - U.S.M.C./U.S.N.
 STAMP II - U.S.M.C./U.S.N.
 Pogo I - U.S.N.
 Pogo II - U.S.N.



PIASECKI AIRCRAFT
CORPORATION

PAGE

REPORT 99-Y-17

ISLAND ROAD, INTERNATIONAL AIRPORT - PHILADELPHIA 42, PENNSYLVANIA

3.3 LOW CASH FLOW

The majority of contracts awarded to unsolicited proposals are usually pared down to below \$100,000 so that the government agency does not have to go through a rigorous, and time-consuming paper determination justifying a sole source award. This justification procedure has grown more and more difficult because there have been a number of violations of the regulations requiring multiple bid requests. These have been mainly by some government agencies desiring to focus their bid to one particular contractor, perhaps because he has expertise, or for other reasons.

Whenever a violation of these regulations is determined, there is usually a purge of the system, which then makes it even more difficult for any innovative idea to go through on a sole source basis.

Hence, the system actually works against its own objective, namely, to protect the R & D funds from going into large single source areas. Perhaps small business submitting innovative ideas should be given a special consideration in the procurement procedure.

Nevertheless, with the limitations of profit (Armed Service Procurement Regulations) ranging from 7 to 11%, the total profit returned on a contract is usually but a fraction of the original cost of preparing a proposal.

With the unsolicited contracts limited to under \$100,000., the profit dollars are insufficient to pay for the proposal costs. Hence, the innovative small company has no way to recover its investment to submit its innovations unless the unsolicited contract can be increased in size or have continuance into larger dollar volume or production.

Therefore, the small business cannot continue to submit proposals in competition with the production companies receiving government IR&D funding, without the growth of the innovation into larger sized efforts, production, or the licensing of other manufacturers. Since the latter cash flows occur long after the start of an innovation, financial assistance is needed at the forward end of the process.



3.4 DEPRECIATION OF PATENTS

In certain parts of our government, a great deal of effort and money is expended towards the encouragement of innovative ideas and the patenting thereof. NSF has made detailed studies, costing millions of dollars, to ascertain the causes of innovation and incentives, including the proper handling of patents, both in and out of the government. (Ref. 20)

However, the pre-procurement practices of some of the government agencies tend to depreciate and make the ownership of patents on the item proposed a serious disadvantage to the proposer.

Further, when a new field is entered (innovation), the government agency usually makes a patent search to determine who has patented prior art on the subject.

Unofficially, plans are formulated to by-pass or devalue the patents in the field. This is sometimes done by declaring the patent holder as having inadequate capabilities or facilities to carry forth his ideas.

Other companies are invited to bid on a government-prepared parcel of work defined around the innovative concept, and thus leaving the innovator behind on the basis of being decreed as unqualified for this work by the government.

In some cases, contracts are let with the specific instructions to its contractors to ignore prior patent-art and to proceed with the use of patents without permission or licensing, with a hold harmless clause in which the government takes the responsibility for the infringement suits that may be brought to bear on the contractor by the innovator or patent holder. (Ref. 22)

As a practical matter, so much time is required to get government acceptance of an unsolicited proposal, evaluation thereof, award of contract thereon, and subsequent repeats of the above process until production results therefrom, that the life of the patent is usually expired (17 years). The life of a patent is too short to provide financial protection to investment in innovation today.



PIASECKI AIRCRAFT
CORPORATION

PAGE

REPORT 99-X-17

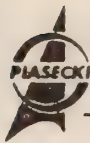
ISLAND ROAD, INTERNATIONAL AIRPORT - PHILADELPHIA 42, PENNSYLVANIA

3.4 DEPRECIATION OF PATENTS (Cont'd)

These practices obviously discourage innovation and work against the small business company, who requires the protection of the patent to benefit from his investment, whilst it works to the benefit of the larger companies who have sufficient resources to take desirable ideas wherever and negotiate or litigate later.

Therefore it is urged that the government establish reforms in the following:

- 1) Cause procuring agencies to respect and encourage patents including their licensing.
- 2) Extend the patent life from 17 to over 25 years.



4. R&D PROCUREMENT PRACTICES NEGATIVE TO INNOVATION

4.1 FRAGMENTATION OF INNOVATIVE IDEAS (LOSS OF IDENTITY)

The government funnels the innovation into a generalized area of technology. If the innovation fits government requirements, the innovative idea can be rewritten, or generalized studies are issued in which the innovations are "amalgamated" and "homogenized" with other proposals. This is done on the basis that the government wants to pick the best of every innovative idea and merge it with others into a "super-idea." The usual result of this type of approach is that the identity of the innovator is lost and the innovation becomes a motherless bastard.

Such an example was seen in the studies leading up to the Advanced Aerial Fire Support System which produced the disastrous Lockheed Cheyenne helicopter.

Another procurement practice, which has been growing in popularity, has been to get related innovations into an overall pot called a "program" in which the innovative ideas are tied in to the overall funding of a large program. This is to obtain an easier way of getting funding for the innovative concepts. However, this approach requires the innovative concept to come under the management of the program manager, which is usually a larger company (and probably competitive) and hence the innovation gets placed into a large hierarchy with very little opportunity for its successful development.

Such an example was the Heavy Lift Helicopter project in which components were developed under the aegis of the "Advanced Helicopter Component Development Program," which in truth had other innovative items added such as a new turbine, new cargo hoisting system, etc.



PIASECKI AIRCRAFT
CORPORATION

PAGE

REPORT 00-X-17

ISLAND ROAD, INTERNATIONAL AIRPORT - PHILADELPHIA 42, PENNSYLVANIA

4.2 GOVERNMENT "MAKE-OR-BUY" POLICY

Although there is a government policy not to engage in in-house work where such work could be done by industry, a large amount of this work persists in government laboratories, test centers, etc. From natural human reactions, this work eventually becomes competitive to alternate proposed systems. Thus, the existing contractors aligned with the in-house work are at an advantage as compared to the innovative systems proposed by the outside industry.

Thus, it is recommended that a firmer policy of make-or-buy decision be instituted to insure full industry participation in the conceptual stages of system design. (OMB #A-76, Ref. 21).

Laws should not permit government work, particularly, research and development, except when industry cannot, or will not, do the job.

4.3 GOVERNMENT EXPRESS NEEDS IN MISSION TERMS

Many innovative design approaches are barred from consideration because of the agencies' pre-occupation and commitment to hardware and equipment terms.

If the mission needs could be expressed in mission terms, innovation and competition in creating and development alternative system design concepts would be encouraged.

This policy has been officially expressed in (Ref. 18) Circular No. 4-109, 5 April 1976, from the Executive Office of the President OMB to the heads of executive departments and establishments on Major System Acquisition Policy.



5. FUTURE NEEDS AND OPPORTUNITIES

5.1 THE NEED FOR VERTICAL LIFT AIRCRAFT

The full importance of moving through the air has not yet been felt by our society. The explosive growth of the jet airline system, replacing the trans-ocean passenger liners and the long distance passenger trains was an immediate and natural improvement by using the much higher speed of the airplane. However, most of the world remains to be developed and cannot wait for nor afford the huge initial investments of expensive jet airports, roads and deepwater docks. Vertical air lift offers the means of transporting in, out and about airportless and roadless areas, providing the final connecting link of transportation from anywhere to everywhere.

Thus the flow of trade can reach infinite numbers of markets and the wildest jungle will be but a backyard. The helicopter has demonstrated the power of such "instant air transportation" in Viet Nam. The technological improvements and growth available to vertical lift vehicles can take them from their current "DC-3" phase to the "jet" phase in a decade or two. Their application will only be limited by society's desire for continuation of man's ability to innovate, and develop.



5.1.1 Military (Cont'd)

The Navy has been outfitting most of its sea going ships to take aboard helicopters for resupply, or their refueling, purposes. This broad use of vertical lift aircraft makes for high flexibility in the fleet. The helicopter has long been a critical element in Anti Submarine Warfare because of its ability to hover and place dunking sonar into the water, as well as perform tight flight maneuvers close to the water with its magnetic detection gear. With the oncoming of smaller carriers, vertical lift aircraft enable more aircraft per vessel with higher performance both in the attack and transport aircraft roles and eventually in the fighter role.

The Marines are already taking advantage of a foreign-developed (but with initial U.S. funds) vertical lift fighter/attack aircraft, the British Harrier. Their use of helicopters for the landing assault functions has also been a dramatic improvement.

The use of modern hybrid lighter-than-air systems have special value in Navy missions of the towing of long arrays for submarine detection. Its long endurance on station, the ability to vertically lift large equipment out of and into the water (such as wide mine-sweeping gear) and the ability to precisely hover over a ship and unload large containers (35-tons) rapidly where no shore facilities are available make lighter-than-air a needed capability. (Ref. 3,4).

The Air Force has similar needs for rapid logistic handling as do all the services.

However, the use of vertical lift systems for construction, installation and deployment of missile silos and missiles can lead to important advantages in

- o Higher protection from indirect hits with silos in mountainous terrain
- o Rapid movement of a reduced number of missiles from silo to silo

Air Force interest is also in vertical lift LTA systems as platforms for high-power laser equipment.



PIASECKI AIRCRAFT
CORPORATION

PAGE

REPORT 99-X-17

ISLAND ROAD, INTERNATIONAL AIRPORT - PHILADELPHIA 42, PENNSYLVANIA

5.1.1 Military Vertical Lift Needs

The Army moving on the ground has fully captured the value of vertical lift to its needs. The Army in Viet-Nam was dependent on helicopter transportation for the movement of its troops and supplies. Several vertical aircraft developments are of highest priority in the Army's new equipment program, the UTTAS and the AAH, the latter being looked upon as our tank killer system. The Heavy Lift requirement still stands but congress withdrew its funding, as well as the ASH forward observation helicopter which requires a far more invisible aircraft than a rotor craft.

In summary, many improvements to military systems have been made by the use of vertical-lift aircraft to the point where these functions rely entirely upon their use.

However, many additional functions can be performed to improve efficiency, particularly in the logistic and construction fields, through the use of heavy vertical air lift. Further improvements to the missions now using helicopters can be made through the use of advanced vertical-lift systems such as the compound (winged) helicopter to provide higher speeds, higher altitudes, and lower maintenance.



AIRCRAFT

Page
99-X-17

5.1.2 Commercial/Industrial

The helicopter has well demonstrated the value of vertical lift in the big job it is doing transporting personnel to offshore oil rigs. (25,000 passengers per week in the North Sea alone).

Airport feeder and inter-airport transportation has been successful in large metropolitan areas of Los Angeles, San Francisco, Chicago and New York. New York Airways alone carried 5 Million passengers since 1952.

However, the largest market for vertical lift aircraft has not yet been touched the inter-city downtown to downtown transport link. There is an urgent need for such service in each megalopolis corridor. Ref. 11.

All the ingredients are available, but a demonstration program with appropriate acceptance criteria needs government support.

The corporate use of the helicopter has been successfully initiated, but these smaller machines lack speed, comfort (vibration reduction) and all weather (IFR) capability which the next research steps have demonstrated (Compound-Helicopter, Ref. 12) but need development into commercial product form.

The Sky-Crane heavy lift helicopter has saved much cost and time in the installation of electric power transmission lines and T-V/Radio towers, transporting air-conditioning equipment to the roofs of buildings, concrete to critical caissons, trees from forests and many other routine functions not capable of being performed by existing methods.

However the Sky-Crane's 10-ton lift limits its application to light loads.

The modernization of lighter-than-air technology in hybrid form combined with the dynamic lift of the helicopter offers a breakthrough in the upper limit of heavy vertical air-lift capacity to payloads of 150-tons and higher.

With such a capability, large indivisible structures can be taken from their factory and directly placed aboard barges or ships for transport near to their destination where a heavy air lift system can lift it off and precision place the load on its foundations.



5.1.2 Commercial/Industrial (Cont'd)

The oil industry has a series of applications for vertical air-lift in survey, exploration, development and logistic roles. Miles of geophone arrays can be laid at one time in ice areas, enabling years' of work to be done in a month. Entire drill rigs can be moved from one drill location to another without major disassembly, enabling impassable terrain to be by-passed. Equipment can be changed on offshore drill rigs with a minimum of time lost, and critical logistic supplies can be delivered when surface systems are impassable.

The construction industry can achieve large economic benefits and reduce the cost of construction on-site by pre-fabrication of beams, floors, modules, etc., and placing them directly into position. Erection of piers, cranes and other dockside equipment can be speeded up, especially where the ground is not solid nor the water all liquid.

Energy plants require such capabilities both in nuclear and fossil installations. Field movement of coal mining machinery is a critical cost item today.

Maritime operations geared to high-speed, non-self-sustaining container ships cannot utilize this major improvement in surface shipping in areas where port facilities are not yet developed. With aerial unloading, the port congestions in Arabia, Nigeria, etc. can be cleared up, making way for more export sales.



5.2 LAND USE AND OTHER CONSUMER DESIRES

Vertical lift offers a reduction in the number of large airports as well as a reduction in the number of flights per airport, as it can take much of the short-haul traffic directly from downtown heliports to downtown heliports.

Thus, on one hand, the noise and its frequency can be eventually reduced in the airport areas, but on the other hand, downtown heliports will bring noise. Noise from vertical lift aircraft is particularly untenable because it is distinctly identifiable as to its source and is closer to buildings and people during take-offs and landings than are airliners.

Land use by vertical lift aircraft will be a constraint involving federal, state and local governments. Demonstration of noise reduction methods is required.

Partial power failures are of particular concern to vertical flights into congested areas. Demonstration of on-hand solutions are required for the safe fly-away and/or landing in the original take-off area of vertical aircraft in congested-areas.

Rotary wing aircraft have high vibration levels and tilt angles at high speeds and transitions. Demonstration of available means to alleviate such deficiencies are required before final public acceptance of vertical lift transports.



5.3 TRENDS IN FOREIGN VTOL R&D

Vertical lift has been a favorite of foreign development programs. Many innovative VTOL aircraft have been brought to flying prototype status overseas because of the low investment required, and some are now competing against U.S. products.

The Russians have been flying the world's largest helicopter of 44-ton lift capacity and are planning to increase this to 65 tons. (U.S. main battle tank weighs 60 tons). Other large helicopters have been flown, produced and utilized in opening up Siberian oil fields. In the LTA field similar efforts are being pursued, while no full-scale development work is yet started in the U.S.

The German firm of Wullenkemper flies three blimps around Europe for advertising purposes and has been awarded a million-dollar grant by the German government to perform a survey tour of the West African Coast. If successful, \$10 million is to be granted for a development project to produce a Heavy-Lift lighter-than-air aircraft of 30-ton capacity. It is also selling the Peru blimps for offshore coastal patrol. MBB has a joint helicopter development with Boeing, Dornier has flown a multi jet VTOL transport and VFW has flown a multi jet VTOL fighter.

Dassault has flown a VTOL fighter, Aerospatiale has a large competitive (in the U.S.) line of helicopter models. The French Government has authorized its Department of Aviation to investigate the design feasibility to carry large nuclear reactor components from their manufacturing plant to operating sites. Aerospatiale has submitted a design carrying 550 tons over 1250 miles at 82 MPH. The studies are continuing to determine costs of operation in 1980.

The British have been investigating the design of several different LTA systems. The heavy-lift cargo use of LTA has been explored by the Airfloat Company, which has proposed a container transportation system from United Kingdom plants directly to various European plants as plant-to-plant delivery service. The Shell Oil Company has commissioned the Aerospace Developments Company to study the transport of uncompressed natural gas, by LTA methods. The British have sold small advertising blimps to Venezuela. Joint helicopter development has been undertaken with the French (Puma, Lynx, Gazelle). Their single jet VTOL fighter, the Harrier, has been adopted by the USMC.



6. CONCLUSIONS AND RECOMMENDATIONS

1. Funds for the development of innovative ideas meeting defined National Needs be provided by the government to small business companies, on a guaranteed loan basis, repayable from the proceeds of the sales of the innovative product.
2. The government's policy on IR&D should be expanded such that it would set-aside a percentage of R&D contracts funds for small business equal to the amount of IR&D funds allowed to production contractors by the government.
3. The unsolicited proposal limitations of \$100,000 be lifted to \$1 Million so that broader innovation aspects can be engaged.
4. The government institute do, make, or buy laws for their requirements. The use of in-house development and in-house engineering should be minimized in order to permit the maximum innovation by industry, outside of the government.
5. Patent life be extended to 25 or more years. Government Agencies to respect patent rights and do not provide indemnification except in time of national emergency.
6. The users of new technology and equipment can permit the full government application of innovation to their problems by stating their requirements in terms of functional performance and not in hardware descriptions, as set forth in White House Order, OMB A-100 (Ref. 18)



PIASECKI AIRCRAFT
CORPORATION

ISLAND ROAD INTERNATIONAL AIRPORT PHILADELPHIA 42 PENNSYLVANIA

PAGE
REPORT 99-X-1

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PIASECKI AIRCRAFT
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ISLAND ROAD INTERNATIONAL AIRPORT PHILADELPHIA 42 PENNSYLVANIA

PAGE

REPORT 99-X-17

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23.	-	DOC	Technology Transfer	S. Sherwin	1976

Mr. Paul H. Poberezny
President, Experimental Aircraft
Association

STATEMENT OF THE
EXPERIMENTAL AIRCRAFT ASSOCIATION
BEFORE THE
HOUSE SCIENCE AND TECHNOLOGY COMMITTEE
April 27-39 and May 4-6, 1976

Mr. Chairman, my name is Paul H. Poberezny, and I would like to submit this statement as President of the Experimental Aircraft Association of Franklin, Wisconsin. The Experimental Aircraft Association has a membership of just over 45,000 and is an unique aviation organization as it has a structure of over 500 local chapters in every state of the union and in many foreign countries as well. We are a truly grass roots organization. Our primary interest is in what we call personal flying and may I take a few minutes to define what we mean by that term.

Personal flying differs from commercial flying as the latter is done for profit or gain. In the category of commercial flying we would include all flying done by the certificated air carriers, travel clubs, charter operators, air commuters, air taxis and all business flying where the airplane is registered in the name of a corporation or company. In contrast, personal flying is done in airplanes owned by individuals. Occasionally or frequently, a personal airplane may be used for business trips but for the most part it is used for the personal convenience of its owner - roughly similar to the use of a personally owned automobile.

It is not our purpose here to discuss research and development programs that are aimed for the benefit of commercial aviation as we have just defined it. But we would like to comment on R & D programs which would be pertinent and important to personal aviation.

It is our belief that government R & D efforts should be directed toward a future air traffic control system that is more flexible than the present Beacon system or the proposed DABS/IPC system. We need more flexibility to handle more aircraft but even more important an ATC system that will permit more direct routing between smaller communities. The present ATC system works tolerably well between large hubs but it does not have the flexibility to handle random movements that are the heart of personal flying. What we envision is some form of cockpit navigation with ground controllers monitoring flights rather than "navigating" for the pilot. A number of systems that can do this have been suggested and the most promising ones should be investigated. A need for a more flexible ATC system was clearly established by an FAA official who said that general aviation may have to be artificially curtailed because the ATC system could not handle it. We do not believe developments in more efficient transportation should be curtailed because of an inadequate ATC system. Let's improve the system to handle the normal demand.

You may question why we place so much emphasis on an improved ATC system in the face of forecasts that the airline fleet may not increase much in numbers during the next twenty-five years - the airplanes will get bigger and carry more people but the

individual flights will be less. We do see a steady increase in personal flying if current developments are allowed to mature. For instance, we do not believe that in this year of 1976 it is prudent or possible to say that man has reached the end of the development of improved transportation vehicles. He has been improving them for 6000 years or more and we do not believe that this development process has now come to an end. As an illustration the flying automobile is technically possible right now and only needs the development of a low altitude ATC system with convenient landing strips that would make it a practical vehicle for hundreds or thousands of families. The flying automobile makes it possible to have door to door transportation at speeds that cannot be matched by automobile or airplane for trips of over 100 miles or longer. The development and use of such a vehicle would revolutionize the transportation habits of this country and make changes in social and geographical living patterns that are undreamed of today.

May we now discuss some specific areas of aviation research and development.

We believe NASA should have the responsibility for basic aeronautical research with the FAA confined to the application of that research. There should be no overlapping of efforts. The EAA membership is in the forefront of design innovations for light aircraft. We need little help from the government except in such areas of original discovery such as the supercritical wing and possibly other areas of development which require elaborate and expensive facilities that are not at our disposal.

Better weather information is most important for personal flying. We understand that there is a government group investigating all forms of better distribution of weather information. We favor the adoption of an 24 hour television weather service on a discreet channel (probably a UHF channel) which would provide continuous pictorial weather information for all classes of users - aviation users, agricultural users, seamen, and businessmen. By providing a single source of weather information for all users the government would save money in comparison with providing several services for different users. A continuous television broadcast would take advantage of the millions of TV receivers already installed. This would make up to date weather information available to pilots and would eliminate calls to briefers and would be a better service than the transcribed reports that are presently available by phone and radio.

While on this subject of weather information for pilots we oppose the FAA spending further funds on the development of a pilot self briefing device as proposed in the Flight Service Station reorganization plan. All these devices that we have seen demonstrated take too much time, are too complicated for the average pilot to use and are too costly to buy and install at most locations.

May we now comment on the FAA proposal to spend money on the development of a Beacon Collision Avoidance System. We think this is the wrong approach for a CAS system for personal flying. Its major drawback is that it provides no protection for small airplanes from each other. The record shows that the major incidents of mid-air and near misses are between general aviation aircraft. This BCAS system would require Mode C altitude reporting transponders. This is an economic burden that thousands of small aircraft could not afford. As an example, FAA records show that there are 26,111 aircraft registered in the active fleet that are over 25 years old and no longer in production. In addition, there are 3,151 sailplanes and 5,058 amateur built aircraft. Therefore at a minimum there are 34,320 aircraft that are unlikely candidates for an expensive Mode C transponder not only from the standpoint of cost but also because many of these aircraft do not have the electrical capacity for a Mode C transponder. If the FAA were ever to require Mode C transponders for all aircraft operating in controlled airspace these older aircraft, sailplanes, and amateur built aircraft and thousands of others would be grounded. We recommend that further funding by the FAA on a BCAS system be eliminated.

We appreciate that Congress has been pushing the FAA for several years to adopt a CAS system that would act as a backup for the present ATC system. We would have no objection to this development and believe that an independent airborne collision system is the best way to go. Several such systems have proved to be practical. If adopted on a voluntary basis such a CAS program would give personal flying no problems.

We note that in the FAA Overview of Engineering Development Programs for 1975-1976 there are ten subjects that are considered as highlights. Most of these programs are designed for commercial aviation and therefore we do not feel it proper for us to comment on them. Others such as the Flight Service Station modernization program and the Collision Avoidance System have already been mentioned above.

Our final subject has to do with Wake Vortex and we are mostly concerned with this program from the standpoint of the hazard that this phenomena causes to light aircraft. We note that NASA has taken a leading part in modifications of aircraft designs which help to relieve this problem at its source. We support the NASA program.

Mr. Chairman, we appreciate this opportunity to express our views on this subject of aviation research and development which is so important to the future of aviation.



EXECUTIVE OFFICES

May 14, 1976

The Honorable Dale Milford
Chairman, Subcommittee on Aviation
and Transportation R&D
Committee on Science and Technology
U. S. House of Representatives
Suite 2321
Rayburn House Office Building
Washington, D. C. 20515

Dear Mr. Milford:

In response to your letter of April 9, enclosed are five copies of a brief paper on what I believe to be an important aspect of the future of aviation in the United States.

Sincerely,

A handwritten signature in cursive script that reads 'Simon Ramo'.

Simon Ramo
Vice Chairman of the Board and
Chairman of the Executive Committee

SR
pd

Enc. (5)

Civil Aviation R&D Policy

This paper will be concerned with only one aspect of this subject, namely, the problem of ensuring an adequate R&D base in private industry. For such a technology foundation to be caused to exist in the U.S. the following factors will have to be recognized:

- (1) High U.S. strength in aviation requires a healthy private sector. Neither total reliance on government in-house activities for R&D in aeronautics nor a nationalization of the aeronautics industry is a politically viable option (even if either were practical from the standpoint of economics and technological organization and recruiting.)
- (2) The technologies of military and civilian aeronautics are not separable in any fundamental sense. Moreover, projects in each category are few in number, with extraordinary benefits realizable through full interchange of information and joint utilization of expertise and facilities. Accordingly, private industry groups active in civilian aeronautics should also be engaged in military R&D and production. Assignment of contracts and allocations of resources should cater to this interrelationship.
- (3) Research, development, design, manufacture and testing of aeronautical equipment (from the overall aircraft to its subsystems and components, including the non-flying portions of any overall system of utilization of aircraft) is an enormously complex activity. It contains numerous highly specialized facets in physical theory, materials, detailed design technology, system interfaces and trade-offs, experimental and testing techniques, analysis of performance and synthesis of highly integrated ensembles. Thus, a private organization operating successfully in this field

as a prime contractor must be large. It must retain permanent staffs of experts in the various disciplines supported by laboratories, computing centers, testing installations, simulators, and a host of other facilities. To stand ready to launch a typical new aircraft program with dispatch requires virtually the same R&D personnel and physical resources as the actual carrying out of the program.

- (4) Instability of funding greatly impairs the health, efficiency, innovative ability, and overall economic and technological performance of private corporations engaged in the aeronautical field. This applies not only to R&D but also to manufacturing. The situation of the last decade or more, and the likely prospects for the future without major policy changes, suggests the U.S. private aeronautical industry will suffer from ups and downs in project starts and terminations, and an inadequate total number of programs, and a poor return on private investment that will make corporate financing dangerously difficult.
- (5) For a stable, high quality aircraft industry to exist in the U.S., one benefiting from the advantages of the motivation of free enterprise and competition, a minimum of three independent, broadly based, well staffed and supported aircraft corporations would appear to be required. The nation today possesses two or three times this number of separate aircraft companies. Some are weak indeed and even the strongest do not possess all the needed ingredients for assured, long term strength. They are not fully utilizing their potential in level and breadth of R&D effort and their inherent capacity for follow-through to production. They are not supported adequately for bold innovative advances.

The above considerations lead to such recommendations as these:

- (a) The government, without applying force and control, should create an environment encouraging, rather than, as now, opposing mergers, aiming for a few (perhaps three) strong aircraft corporations. This may require new legislation since the final public interest in this special case may not be served by present antitrust laws or their interpretation.

The companies would compete, of course, each seeking by the quality of its performance and ideas to gain a larger share of the total government funding and private contracts.

- (b) The government should plan a program of multiple year funding to ensure a stable and adequate R&D program for the companies created by the combining recommended in (a) above. There should be a commitment by the government to the goal of so scheduling projects - both R&D and production - as to include as an imperative criterion an evenness of backlog for the corporations selected for long term participation. (This criterion is to be, of course, in addition to the existing and continuing other criteria of the market's requirements for civilian passenger and freight transportation, military needs, environmental and budgetary considerations, etc.)
- (c) The "favored" private corporations, as they compete both for R&D and production funds, may be expected to vary as to their overall contribution and as to their financial performance. Presumably there will be some relationship, though it may be complex, amongst their record of return on assets employed, their ability to raise capital, and the quality of the products they turn out. From time to time it may be seen that one or another of these corporations is performing below an acceptable range by any of the several criteria to be applied. Accordingly, the government must have means for continuing evaluation; it should be prepared to take additional steps to ensure that at least three strong competitors always exist.
- (d) The aeronautical industry needs to include, in addition to the very large corporations who produce an integrated aircraft system, a host of smaller and/or more specialized industrial and other organizations to provide components, subsystems and technological advances in unique areas. It is believed these corporations will be greatly enhanced in vitality and contribution if there will exist some large, high-quality, thoroughly viable aircraft corporations.

Thus, no special recommendations re these other organizations are offered except as to one point. R&D funds from the government cannot be expected to filter through adequately from the large aircraft companies to these specialized suppliers and supportive organizations. Thus, a separate well-financed, steady government program of supporting R&D is recommended also for this vital segment of the private sector.

Simon Ramo
5/14/76

HELICOPTER ASSOCIATION OF AMERICA

1156 15TH STREET, N.W., SUITE 610, WASHINGTON, D.C. 20005 202/466-2420 • TELEX 89-615

May 14, 1976

EXECUTIVE DIRECTOR
ROBERT A. RICHARDSON, C.A.E.

The Honorable Dale Milford, Chairman
Subcommittee on Aviation and Transportation R & D
Committee On Science and Technology
U.S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, D.C. 20515

Dear Representative Milford:

Please find enclosed some information from our membership in response to your request for views on the "Future of Aviation" as outlined in your letter of April 14, 1976.

Exhibit 1 is a brief memorandum prepared by Boeing Vertol Company which will hopefully be of benefit to you and the committee. In addition to the memorandum, Boeing Vertol believes the salient points to be:

Helicopter R and D will be primarily funded by the military for the foreseeable future.

NASA will have a specific role to play, both with the military and by itself.

NASA must more clearly define this role in civil helicopter development and should devote more of its resources to rotary wing R and D.

Both NASA and DOD sponsored R and D should primarily be accomplished by R and D contracts with industry.

DOT and NASA should conduct concept formulation studies to determine specific civil requirements

The military, by and large, have well-defined goals as to where they want to go. There are long range research plans which are accomplished by a combination of in-house efforts, contractual R and D with industry and by industry Independent R and D. The civil side, on the other hand,

cont'd

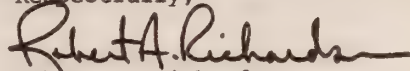
is more uncertain in its goals. Nevertheless, there will assuredly be dramatic expansion in the civil helicopter field, the degree being largely dependent on the capability of research and development to provide comfort, cost and safety comparable to that of fixed wing aircraft. This must be accompanied by substantive government subsidies to aid in the purchase and operation of civil helicopter fleets.

Exhibit 2 is a brief position expressed by Detroit Diesel Allison Division of General Motors on national civil aviation R & D policy. Due to the limited response time this company only addressed themselves to Item VI in your Guidelines for Papers entitled "Industry View".

Thank you for this opportunity to respond to your study of the "Future of Aviation". I expect to receive some additional input from our members. Rest assured that it will be brought to your attention immediately.

Kindest personal regards.

Respectfully,


Robert A. Richardson
Executive Director

RAR:ag
Enclosures

PROFESSIONAL HELICOPTER OPERATORS

FUTURE DIRECTION OF CIVIL HELICOPTERS

Progress in helicopter technology and production of large numbers of rotary wing aircraft have been primarily due to the military requirements for this unique capability, particularly suited to their operational needs. Most commercial rotary wing aircraft have been spin-offs of military models because of the limited commercial market and the high cost of research and development. Even with the military model being the base machine, there has been continued growth in the civil helicopter field and the future portends even greater expansion. A word of caution is necessary relative to the rate of expansion as optimism must be tempered with a realistic assessment of the market. Growth depends to a great extent on the cost, convenience and safety factors that will be developed for the helicopter of tomorrow.

Civil helicopter current and projected functions are as follows:

- o General aviation-type aircraft. This is the largest market and includes executive transport, medical ambulances and government usage in such diverse areas as police and forest ranger work. Because of the small size and relatively low costs, this will be the most volatile future market.
- o Industrial helicopter. This function will be accomplished by UTTAS-type aircraft and be primarily used in off-shore oil operations and in other areas where there is limited surface access, such as in mountainous, arctic or tropical environments. A limited number of this type of aircraft will cross over to the general aviation/non-military government category.

- o Short haul (passenger carrying) transportation system. This has long been predicted as the greatest growth potential but progress has been limited and the future is questionable. The real hope lies in reduced costs and the development of an integrated inter-modal transportation system. This requires detailed concept formulation by DOT and NASA with industry assistance and significant government resources to put any viable plan into effect. A possible approach would be for an integrated terminal to be built at Penn Station in New York City with bus, car, rail and helicopter transportation collocated; similar facilities could be established at the 30th Street Station in Philadelphia and at Union Station in Washington. This integrated inter-modal system would suffice for the north and central eastern seaboard and perhaps in California but would not be practical for routes requiring longer hauls. Without such an integrated system, short haul helicopter passenger transport will grow at a slower pace.

DIRECTION OF HELICOPTER
R AND D

The U.S. Army is currently engaged in the largest helicopter R and D activities ever undertaken with the Utility Tactical Transport Aircraft System (UTTAS) and the Advanced Attack Helicopter (AAH) representing a total of over \$1 billion in Research and Development funding. The civil version of the UTTAS will have direct bearing on commercial helicopter application as it is the appropriate size for industrial functions;

while there is no direct civil application of the AAH, the technology will spill over to the commercial field. In spite of this extensive development effort, continued research is required specifically for the civil helicopter. Attention must be paid to the comfort factor of current helicopters which may be satisfactory in a military combat environment but which needs considerable improvement for civil acceptance. Specific civil R and D goals are:

- o Reduce costs. Transmission costs can be reduced 30% with advanced technology; blade costs can be reduced to \$50-75 a pound with fiberglass fabrication offering the possibility of blade life being identical to the life of the airframe; airframe costs can be reduced by modular fabrication and use of composites; maintenance costs can be dramatically reduced by a factor of 50%.
- o Operational Enhancement. Vibration levels and the noise levels - both external and internal - should be reduced to civil acceptance levels. An IFR capability must be developed permitting touchdown at minimums amounting to practically zero-zero. The helicopter accident rate should be equivalent to that of fixed wing aircraft; a rate of one per 100,000 civil helicopter hours should be attainable. Research should investigate increasing cruise speeds to at least 175-200 knots without adding to the complexity of the machine.

The results of this research should produce a civil helicopter with expanded functions and attendant expanded usage.

HOW CIVIL HELICOPTER R AND D CAN BE ACCOMPLISHED

A great deal of commonality exists between civil and military helicopter requirements but there is a clear-cut role for civil research and development. NASA has largely "piggy-backed" on the military and has minimized its role in rotary wing development. NASA has recently, in conjunction with the Army, devoted considerable funding for a Rotor Systems Research Aircraft and Tilt-rotor activity. Even considering these "large" expenditures, they are small in comparison to fixed wing development. And the large expenditure on two total aircraft systems has reduced the amount of funds that might be devoted to basic or exploratory research. NASA should not duplicate the activities of the military and should continue to participate on joint development programs as they have in the case of RSRA and tilt-rotor. This joint pursuit of basic research appears to have given a significant impetus to NASA research. But NASA should also concentrate on basic helicopter R and D. There is need for more rotor airfoil research as well as rotor noise abatement, vibration reduction, increased speed, and improved safety - all of importance in the civil helicopter field. The results of such research will dictate new requirements for the civil helicopter by impacting on widespread public acceptance of the aircraft.

It is obvious that close coordination of NASA and DOD research and development is essential. Such coordination is being conducted but high-level reviews appear a logical means of avoiding duplication, particularly if increased NASA rotary wing funding occurs.

FUTURE OF AMERICAN HELICOPTER INDUSTRY

The future helicopter industry base will consist of U.S. military, commercial and foreign military superimposed on each other. There are four major U.S. helicopter producers at the present time and the competition is good for the industry and the customer. Two are competing for the large UTTAS contract and the other two for the equally large AAH contract. It is in the government's best interests to ensure that the helicopter industry remains competitive and that the four suppliers for the expanding future market remain in tact. There is no doubt but that competition reduces costs and improves the technical capability of the helicopter. Suggestions have been made in the Defense Department that a two company industry might evolve after the decisions on the UTTAS and AAH and that DOD might encourage this concept. The dropping out of participants in the helicopter industry could lead to an uncompetitive situation, subject to an inundation of government regulations and controls that could stifle initiative. The best solution is the retention of a firm helicopter base of four major companies which will maintain competition in cost and technology and with a capability of expansion of the base in the case of national emergencies. Such competition is equally applicable to the civil as well as to military development and production.

The current outlook for the civil aviation market is clouded by the future impact of the energy crisis and the uncertainties of future airline growth combined with the current financial instabilities of the airlines and apparent over-capacity.

The softness of the civil aviation market has created a high level of risk in the development of future civil aviation products. This risk is further elevated in the 1980 plus time period by the divergence of the U.S. military technology goals from those required for civil aviation in the same time period. In the past, the civil aviation manufacturers have been able to initiate commercial development programs with the normal business risks on the basis of military developed technology. Without the fallout from prior military technology and development programs, the business risks associated with the development of commercial aviation products may become unacceptable as a sound private venture.

Currently U.S. manufacturers lead the world in helicopter development and production and export a large part of their yearly production. However, to maintain the favorable balance of trade created by demand for U.S. helicopters in the world market, it is imperative that U.S. manufacturers with the assistance of government development programs meet and overcome challenges from overseas.

If the foregoing postulations are reasonably valid, then it would follow that a civil aviation policy or goals should be established. From the viewpoint of a propulsion manufacturer, the logical focal point would be NASA wherein the background and capability currently exist. NASA's propulsion

oriented research centers could fulfill the same role for the civil aviation field that the Aero Propulsion Laboratory fills for the Air Force. The current NASA efforts are insufficiently funded to provide for other than research oriented programs. The NASA effort could be expanded to provide cohesive programs directed to definite objectives which are necessary to maintain the U.S. leadership in the world commercial aviation market.

To achieve this goal, the NASA charter must be expanded to allow development effort equivalent to military advanced development with definite products in mind. However, these efforts should be limited to those areas which are beyond the capacity of industry.

In general, the current NASA programs address the foreseeable needs of the propulsion industry in terms of advanced technology, i.e., SST, STOL, EEE, and general aviation. However, the level of activity in any area is limited by fiscal resources and the lack of a dedication to practical application.

In no way do we intend to imply that NASA should be established as a product development agency. It is intended that a greater emphasis by NASA should be applied to the development of a technology base which would provide advanced components for civil aviation at a normal business risk and would enhance the national civil aviation position.



CIVIL AERONAUTICS BOARD
WASHINGTON, D.C. 20428



June 3, 1976

IN REPLY REFER TO: B-1-62

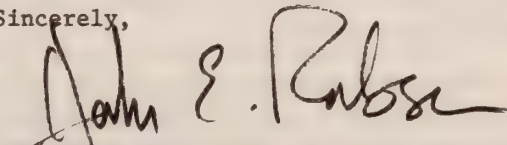
Honorable Dale Milford
Chairman, Subcommittee on Aviation
and Transportation R&D
Committee on Science and Technology
House of Representatives
Washington, D. C. 20515

Dear Mr. Chairman:

This is in response to your letter of April 27, 1976,
requesting the submission of a paper concerning the "Future of
Aviation" and, more specifically, national civil aviation research
and development policy.

We hope that this paper will assist in policy formulation by
providing some insight as to the ways in which the Federal economic
regulation may influence the commercial aviation research and
development process.

Sincerely,


John E. Robson
Chairman

Enclosure

Mr. John E. Robson
Chairman, Civil Aeronautics Board

The Subcommittee on Aviation and Transportation R&D is examining the "Future of Aviation to define the elements of a national civil aviation R&D policy that can sustain the aviation industry into the next century."

A major controlling element in commercial aviation is the Civil Aeronautics Board which is vested with the responsibility for economic regulation of commercial air transportation. The CAB is not authorized to sponsor or control aviation R&D directly. Nevertheless, economic regulation has a bearing on the R&D process. Economic regulation affects the market for air travel and the structure of the airline industry, and thereby the technological needs of commercial aviation. Accordingly, for civil aviation R&D to be responsive to the changing needs of commercial aviation, it must take into account possible changes in the regulatory environment.

It is important that the Subcommittee on Aviation and Transportation R&D recognize possible changes in the regulatory environment in developing aviation R&D policy. Specifically, there exists the possibility that Congress will alter the regulatory policy for air transport. At present, there are two bills proposing significant regulatory changes under consideration by Congress, the Aviation Act of 1975 (H.R. 10261), and the Air Transportation Act of 1976 (S. 3364), as well as the Legislative Regulatory Reform Program of the Civil Aeronautics Board. All three propose reform in the direction of greater reliance on market forces. These programs for reform are based on the analysis that greater reliance on market forces will promote cost efficiencies, stimulate demand for air travel, and, ultimately will better serve the public interest and improve air carrier profitability. The ability of aircraft manufacturers to develop new airplanes and to remain technically competitive in a world market are directly associated with the financial health of the airline industry.

The relationship between economic regulation and technological development is complex. Nevertheless, ascertaining this relationship would appear to be important in developing both regulatory and R&D policy. Two areas deserve particular attention: the direction of future R&D and the institutional arrangements by which R&D receives direction and funding.

A more competitive regulatory environment may influence technological needs, including the character of the aircraft required. The Board believes that one effect of the present system of regulation has been to induce service competition as opposed to price competition. As price competition emerges in the commercial air transport system, one might expect some shift in the character of aircraft required by airlines from those employed in an environment of service rivalry. In the later 1960's most major U.S. commercial aircraft development programs, incorporating very significant technological advances, focused on large, long-range aircraft. This was in part

owing to the fact that, under regulation, fares for longer routes and denser markets were higher relative to cost than fares in shorter, lower-density markets. The greater "profitability" of longer, denser markets may have biased aircraft development in that direction. Under greater competition, this discrepancy will presumably disappear. If other types of markets become relatively more profitable, one might expect development aircraft suited for these markets.

Aircraft manufacturers can design specialized aircraft to serve a specific type of market or they can design a general type of aircraft suited to a variety of markets. Their development and production decisions depend on the structure of the air transport system and the consequent demand for various types of aircraft. If, in an environment of increased competition, the present linear network of routes and wide range of markets is maintained, more general types of aircraft would be called for. Conversely, if demand for turnaround service increases, air carriers may require specialized aircraft that are capable of realizing economies in limited markets. General purpose aircraft designed to serve a variety of markets could become economically less desirable for operations in a competitive environment with more, cost effective, specialized aircraft.

Commuter carriers and air taxis are presently restricted to aircraft of 30 seats or less and possessing a maximum payload of 7,500 pounds, if they wish to remain exempt from Federal regulation. All three reform proposals cited above suggest an increase in the exemption to aircraft of 55 seats of 16,000 pounds of payload. This may ultimately encourage the development of new somewhat larger aircraft to serve small markets. Aircraft in the 15-30 seat range are predominantly used by commuter carriers and many believe that this is the optimum size for such markets. However, it has been the experience with commuter carriers that they have carefully tailored their equipment to their market needs.

Another possible effect of changed regulatory environment on the direction of aviation technology, is on the institutional arrangements by which aviation technology is guided and funded. Characteristically, the larger air carriers in the airline industry, which has traditionally been concentrated, placed advance orders that have induced aircraft manufacturers to make substantial investments in the production of new types of civil aircraft. An initial period of uncertainty over the potential impact of heightened competition could diminish incentives to underwrite the development of new aircraft. However, beyond a possible period of uncertainty, if the regulatory environment is altered to one that is more competitive, then the industry may evolve to one composed of smaller and medium-sized carriers, as some have speculated, or it may remain relatively concentrated, as others have speculated. In a less concentrated industry there may be less opportunity to place large advance orders

that the overall demand for new aircraft may be greater. Devices such as a consortium of carriers might sponsor aircraft development. If however, the industry remains relatively concentrated, the larger carriers should be able to place large advance orders.

It should be pointed out, however, that the basic decisions by aircraft manufacturers to enter production of new aircraft are based on a number of factors, only one of which is advance orders, and the most important of which is the manufacturer's assessment of the size of the ultimate market for the plane.

In sum, future advances in commercial aviation technological development will depend in part on airline demand for equipment which is, in turn, influenced by economic regulation. The relationship between economic regulation and aviation R&D must therefore be taken into account in the formulation of R&D policy.

TRANS WORLD AIRLINES

KANSAS CITY INTERNATIONAL AIRPORT

P. O. BOX 20126

KANSAS CITY, MISSOURI 64195

R. W. Rummel

VICE PRESIDENT

TECHNICAL DEVELOPMENT

May 14, 1976

The Honorable Dale Milford
Committee on Science & Technology
U. S. House of Representatives
Suite 2321, Rayburn House Office Bldg.
Washington, D. C. 20515

Dear Congressman Milford:

We are encouraged by your subcommittee's intent to examine the "Future of Aviation." The U. S. aerospace and airline industries represent an extremely complex environment of technology and economics that demands your most careful analysis. I am grateful to have this opportunity to submit my comments.

The subject is timely and controversial, and its resolution is critical to the national interest. As I look to a direction for the future of aviation -- together as part of the aerospace industrial group, or separately as individual companies -- I have recommended that we become rabid environmentalists. By that I mean serious and dedicated defenders of an endangered species - aviation technology.

There seems to have developed an open season on corporate policy and profitability, and our aviation habitat is a Federally controlled preserve where misguided advocates feel free to hunt without limit, with no license requirements other than the desire to shoot for political gain, and where international poachers are allowed to roam without equitable restriction.

We are witnessing the decline of an industry - airlines and aerospace manufacturing industries - which through years of aggressive pioneering undertakings have produced the finest transportation system ever known. The safety, convenience, comfort and reliability standards established by U. S. air transportation, and the aircraft developed by the U. S. manufacturers are without parallel as demonstrated by dominant world-wide usage of U. S. aviation products which, not incidentally, produced a very improved contribution to the balance of payment record for our nation.

How is it, then, that this industry, which has grown to be a vital element in this nation's and the world's economy, is now to be concerned with survival? In a word, economics.

Because of years of depressed airline earnings which since 1970 measure \$4.3 billion less than the CAB's recommended reasonable rate of return; because of consecutive years of failure to achieve fare increases to offset inflation influenced expenses; and because of a nearly complete loss of investor confidence stemming not only from negative earnings but also from the uncertainties relating to the currently threatened senseless undermining of the basic structure of the airlines by changing the rules under which the airline industry has grown -- the so-called deregulation of the airlines.

There are other factors, to be sure, but these should head the list on today's aviation environmental impact statement.

The financial strength of the U. S. airline industry has eroded to the point that future growth leans on a very shaky foundation of debt and uncertainty. General economic recession and inflation have also aggravated this situation. The proposed re-structuring of the airline industry undermines any reasonable business outlook for major airline fleet additions, and the development of new types of transport aircraft.

The key to maintaining a strong airframe and vendor industry able to satisfy the needs of the U. S. and to cope effectively in the world marketplace is the return to profitability of the U. S. airline industry. U. S. leadership in aviation must be constantly earned - it did not happen by accident and it will not be sustained by inaction. For example, aircraft 40 percent more energy efficient can be developed today, but not without customers with money. New or derivative aircraft design/production programs will not be possible until the confidence of the financial community in the airlines is restored. This requires regulatory stability and reasonable airline profits.

Further complicating the future of the industry is the fact that the airlines face the threat of a whole series of mandated retrofit orders, the cost of complying with which would far exceed the industry's financial resources -- even in good economic times. At the moment, the FAA has under consideration various directives requiring the airlines to make major modifications in the name of noise reduction and safety. Obviously, noise and safety are important issues. But there is no such thing as absolute safety or complete absence of impact on the environment.

These issues must be kept in perspective. Many proposed changes provide only minimal improvement in either safety or environmental impact and yet carry astronomical costs. For example, the proposed engine noise reduction program alone would cost the trunk lines over \$1 billion, an impossible amount to finance. And that would be for almost no perceptible reduction in present noise levels. On top of this, proposals to replace aircraft interiors in the interests of fire and toxicity prevention would cost added billions, and with marginal improvements in safety.

The current situation can be summed up this way:

- . Until a reasonable level of profitability is allowed and sustained by the airlines, the airline industry will be unable to sponsor new, advanced aircraft development programs.
- . Therefore, the U. S. airframe manufacturers are now and apparently will remain unable to launch new transport aircraft programs because of lack of airline customers.
- . Rates of aircraft production at Boeing, McDonnell-Douglas and Lockheed continue to decrease. Some production lines are critically close to shutting down during 1977. Without additional transport aircraft development programs, the U. S. manufacturers will be unable to maintain experienced and effective design/production teams and facilities. These capabilities are an important national asset which cannot be readily re-established.
- . The timely development of more energy efficient, ecologically acceptable and economic aircraft is clearly in the best national interests of the U. S. Essential technologies are well advanced. However, the development and production of such aircraft in the U. S. is not apt to occur until the confidence of the financial community in the airline industry is restored.
- . We badly need both a more critical view of cost-benefit relationships and a recognition by the government that retrofit requirements mandated in the public interest should be publicly financed.
- . The historic formula for the development of U. S. transport aircraft, i.e. private ventures involving the manufacturers working directly and in close liaison with airline customers supported by a solid foundation of Federally sponsored technology development, has repeatedly produced the world's best aircraft. This practice has no parallel in other countries. There is no reason to change the successful formula.
- . The European airframe industry, supported by its governments, is preparing to develop new transport aircraft in furtherance of its ambition to capture a larger share of the world aircraft market. It has adequate technical and financial capability to do this. The potential adverse balance of trade impact on the U. S. is obvious.

The Honorable Dale Milford

Page 4

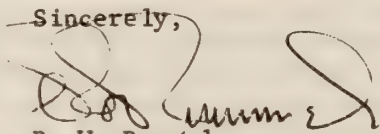
May 14, 1976

Hopefully, out of your subcommittee's deliberation will come some constructive, helpful viewpoints on the best way to restore and maintain the long term health of the U. S. airlines and their supporting industries. Those of us who make our livings in air commerce and air transport production are holding similar discussions within a variety of industry forums. We are fighting to survive in a very complex environment until we can regain public, regulatory and legislative understanding of our need for responsible growth.

Any failure in this process could commit still another U. S. industrial asset to the international chopping block. Ours is the kind of country that invents the steamship, then presents its whole maritime industry to the other nations of the world and becomes dependent on them for our shipping.

May I again express my appreciation for having been afforded this chance to speak to the issue.

Sincerely,



R. W. Rummel

Abe Silverstein

21160 Seabury Avenue
Fairview Park, Ohio 44126

May 6, 1976

Honorable Dale Milford, Chairman
Subcommittee on Aviation
and Transportation R&D
Committee on Science and Technology
U.S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, DC 20515

Dear Chairman:

I appreciate this opportunity to offer comments pertinent to your examination of the "Future of Aviation" and to define certain elements that I think are important in the establishment of a national civilian aviation research and development policy. The growth of civil aviation in the United States and throughout the world for the past forty years has been phenomenal and the United States has led the world.

In its beginnings, civil aviation was undergirded by a strong military research and development program and by the basic and applied researches of the National Advisory Committee for Aeronautics. Effective programs for the development of propulsion systems, structures, and materials enabled a continuous progression of ever improved aircraft to be developed and produced by our aircraft industry. A policy by the military services that allowed industry to use a certain percentage of their contract dollars for in-house research and development spurred the growth of new technology. One reward for these efforts which were supported continuously over many years is the current crop of magnificent transport aircraft including the 747, DC-10 and the L-1011.

There is a need for a continuation of this growth in transportation as represented by ever better aircraft and for the continuation of American leadership in world aviation. Research in progress shows a clear direction for development of the next generation of transport aircraft that will maintain our supremacy in the skies for the next forty years. Much work remains to be done before these research concepts can be translated into development and production hardware but a start has been made.

The market for this new and advanced generation of aircraft is assured. It seems clear to me that the rate of growth in aviation between now and the end of the century will exceed the rate of growth in world population. As a minimum I would expect that requirements for commercial aviation equipment and services will be at least three times their current size by the Year 2000. This market will be supplied by those who have the best products. Our national policy should be directed toward capturing this market by continuation of the activities that have established leadership for this nation up till now. Clearly, this involves strong support from NASA's research and development programs, for university contributions to basic research, and for independent research and development contributions by industrial contractors.

Beyond this point, however, a problem arises for which as yet there is no solution. The costs for developing new transport aircraft have become so large relative to the capitalization of the industrial organizations responsible for their development that it is becoming increasingly difficult for industrial organizations to develop large new aircraft without risking bankruptcy. The risk in these developments is heightened when more than one aircraft organization enters the competitive market and reduces the sales opportunities for the new aircraft by dividing the market. These risks in prototype development are so high that aircraft companies may be unable to get permission from their directors to gamble on success.

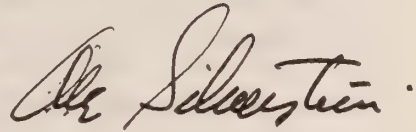
It would appear that legislation may be required to establish some new method for creating future prototype and development aircraft in the large transport class that will reduce this inordinate risk by the participating contractors. For this purpose it may be desirable to create by legislation a corporation owned by a consortium of the principal aircraft manufacturers, the United States Government, and the public. The combined scientific, technical, administrative, and manufacturing talents of all participants will be directed toward the creation and production of advanced transport aircraft. The corporation might be modeled after the communication satellite corporation (COMSAT). The corporation would use the developmental and manufacturing talents of the existing aircraft industry on a competitive basis.

It seems clear that this kind of consortium (or some other kind) is required if the job of moving ahead in aviation is to be accomplished. It is also essential that action in this direction be taken quickly so as

-3-

to forestall the loss of our leadership position in the world to a combine of foreign builders. Their competence in the construction of the Concorde aircraft has been demonstrated. Their choice of the Concorde for a combined effort was unfortunate. Their next effort may be on target.

Sincerely,

A handwritten signature in cursive script, reading "Al Silberstein". The signature is written in dark ink and is positioned to the right of the word "Sincerely,".

AS/cl

LOCKHEED AIRCRAFT CORPORATION

BURBANK, CALIFORNIA 91503

RONALD SMELT
VICE PRESIDENT
CHIEF SCIENTIST

12 May 1976

The Honorable Dale Milford
Committee on Science and Technology
U.S. House of Representatives
Suite 2321, Rayburn House Office Building
Washington, D. C. 20515

Dear Congressman Milford:

Responding to your letter of April 9, I am very pleased to be given the opportunity to participate in the work of your Subcommittee on Aviation and Transportation R&D, and to contribute to its hearings on the "Future of Aviation." This examination of the current state and future outlook for our aviation industry is indeed timely. As you indicate in your thoughtful article in "Astronautics and Aeronautics," April, 1976, without some serious national planning, the nation's aviation industry will soon suffer the same fate as the railroad industry. There is an urgent need for a searching re-examination of the role of government and the legislative process in our aviation world.

This same conclusion, particularly in its application to aeronautical research and development and the future of NASA, emerges clearly from the results of the excellent study "Outlook for Aeronautics," just released by NASA after almost two years of comprehensive analysis. Since the work of the NASA study team will undoubtedly be a major input into your Subcommittee deliberations, it is clearly unnecessary for me to review the details of their conclusions in this letter. I should emphasize, however, that NASA's Research and Technology Advisory Council, of which I have the honor of acting as Chairman, has reviewed the work of Dr. Len Roberts and his NASA colleagues on several occasions as they developed the "Outlook for Aeronautics." We are in general agreement with their prognostications for the future, and with their recommendations regarding future aeronautical research and technology and the role of NASA.

By way of introduction to my own views on the present aeronautical scene, I would like to quote rather extensively from a classical document:

1. On the Need for Government Cooperation and Support:

"For cogent economic, military, and political reasons, it is essential that the United States maintain its long-held position as the world's leading developer and builder of aircraft. This preeminence should encompass all of the major categories of civil aircraft. Progress in this area is determined by research and development leading to an improved state of the art, by the effect of competitive and marketing factors on production and, perhaps most important of all, the degree to which a sense of urgency is applied to the foregoing factors."

"Clearly, the United States can no longer take its preeminent position for granted. The U.S.S.R. has strong political motivations to obtain a more significant share of the market, and the improved Soviet designs and productive ability are generating competitive strength. Foreign manufacturers in the Western countries already are competitive in some types of equipment. While the United States cannot inhibit the attempts of other free nations to expand their exports, it can hardly let its own market position deteriorate, especially since this would have such wide economic and political ramifications."

"It is imperative, therefore, that our manufacturers regard their domestic market, far larger than that of any of their competitors, as an economic base from which to venture forth into the more difficult export business. The need for accelerated development of V/STOL and other short-haul aircraft, emphasized elsewhere in this report, is a pertinent example."

"Much will depend on vigorous and enlightened Government cooperation and support. Government activities of many different kinds affect the prospects for exports of aeronautical equipment. While many manufacturers have their own sources of market information, few can cover developments all over the world. Appropriate personnel in the Government's embassies and consulates can make a most

important contribution. They need to be alert to opportunities for sale of U.S. aeronautical products--military and civil--and the information they acquire must be passed on expeditiously."

"Diplomatic and technical missions abroad can also help support the sales efforts of U.S. manufacturers and U.S. airlines. While they quite properly avoid favoring one U.S. supplier over another, they need not refrain from supporting U.S. products against foreign competition. To assure that they do as much as is compatible with our national purposes, our missions abroad need to be made aware of the national interest in aeronautical exports."

2. On the State of the Aircraft Manufacturing Industry

"U.S. leadership in civil aviation for the past 30 years can be traced, in large part, to a vigorous aircraft industry which had the skills and the resources to develop, produce, and market a series of outstanding civil aircraft, engines, and aeronautical equipment. Our future leadership is likewise dependent upon a manufacturing industry that is strong enough not only to continue past rates of civil aircraft and equipment development but to accelerate them."

"Three events or trends of the past few years have affected the ability of the manufacturing industry to meet this challenge. These are the decline in the requirements for military-manned combat aircraft; the accelerating diversification of many aviation companies into non-aeronautical areas; and, finally, the substantial losses incurred by those companies which participated in the most recent round of jet aircraft developments."

"For major civil aircraft developments, the cost of bringing a new product to market is likely to run into millions, or even hundreds of millions of dollars. The manufacturer who undertakes such a development program with his own resources must not only see an adequate market in aggregate, but must also make a judgment about his own chances of capturing a profitable share

of this market. In the case of the large turbojet and turboprop aircraft, for example, the four U.S. manufacturers have thus far written off more than ___million in losses. While some of this can be traced to underpricing and to technical problems, much of it is a result of splitting a relatively restricted market among a number of competitors so that only one manufacturer has even approached a break-even volume of sales. The experience of the manufacturers in the subsonic jet program will certainly affect their approach to any large future civil aircraft development program."

3. On Regulation and the Airlines

"The present low level of earnings of the industry, if continued, threaten its entire financial structure. In addition, certain carriers are plagued with acute financial problems. The present and prospective airline financial posture is of importance in two major aspects. First, the carriers' financial condition is, in part, a reflection of, and has implications for, the nature and extent of regulatory action by the CAB in such areas as routes, competition and fares. This is not to suggest that the carriers themselves do not have primary responsibility for their financial condition and structure. It is simply a realistic assessment of the pervasiveness of regulation in the affairs of the airlines. Second, the current airline financial posture has long-run implications with respect to the ability of the industry to purchase and absorb, on a timely basis, new types of aircraft and equipment when they become available."

"Restoration of sustained earning power and the development of profitability to the required levels are essential for attracting and retaining the capital necessary to develop a stronger airline group better able to enter the supersonic transport age. Earning power--past and present--is the fulcrum upon which the financial fortunes of the airlines rest. Airline capital structures in all their elements are dependent upon earning power. Any influence which serves to undermine or destroy earning power threatens the financial solvency of the industry. The degree of profitability which ensues in the intervening

years will, of course, determine the industry's ultimate financial position, and hence, its capabilities to purchase and operate supersonic transports and other next-generation aircraft."

4. On Aeronautical Research and Development

"An adequately funded, prudently managed, continually updated research and development program of breadth and imagination is essential to the maintenance of U.S. world leadership in aviation. As in other fields of science and technology, to be most effective this effort must be properly coordinated and carefully balanced in terms of emphasis on basic research, applied research, development, test, and engineering. A disproportionately large basic research program may advance the frontiers of the fundamental sciences which underlie aviation technology, but, without a properly matched applied research and development effort, technology (which in the end results in useful aviation products) may lag, to the competitive disadvantage of the United States."

"On the other hand, a research and development program which neglects basic research may make short-term competitive gains in useful products but will bog down in the long run because the frontiers of basic knowledge have not been advanced."

"Federal Government responsibility for aviation research has long been recognized and its participation in such research has been extensive. In the past, however, Government-sponsored aeronautical research has largely been stimulated by military requirements for advanced manned aircraft. In recent years this stimulation has declined as a result of the growing concentration on development of missiles and space systems by the military and by the National Aeronautics and Space Administration. It is no longer possible for civil aviation to progress by placing main reliance on using the byproducts of military-related research and development programs."

"A new rationale to define justifiable areas for Federal support for essentially civil aviation research and development requirements may be in order."

5. On Areas of Aeronautical R&D

"Subsonic, propellerless, turbine-powered aircraft will be the backbone of our domestic and international air carrier fleets. These vehicles can be greatly improved in terms of efficiency, reliability, and performance."

"A question of major importance is whether the Nation should proceed with the development of a supersonic transport, and, if so, what design criteria should be established for the development program. Beyond the economic and social justification for the development of a supersonic transport, international prestige considerations argue heavily in favor of going forward with the development of such an aircraft on a timely basis. Finally, a fleet of supersonic transports would represent a significant military asset. For these and other cogent reasons, the United States should begin immediately an intensive applied research program to establish the preferred design parameters for a mach 3 supersonic transport."

"The suggested applied research program should encompass several critical areas. Major emphasis should be placed on determining the optimum engine cycle in view of the long leadtime required to achieve a satisfactory powerplant, and the critical dependence of the airframe design upon the characteristics of the propulsion system chosen."

"In this program the Government must not only serve as a catalyst to secure an early launching of resources into a specific development program, but must also provide a substantial portion of the financial resources. This is especially true because the post-development manufacturing costs of a fleet of supersonic transports would, in and of itself, tax the financial capabilities of any single airframe company or group of companies. This is not to say that the industry cannot and will not provide any of the development funds for the supersonic transport, since clearly it can and should. Nor is it to say that the Government should not seek to recapture at least a part of its development stake through royalty payments on completed supersonic transport aircraft. It does imply, however, that Government must, in the

first instance, supply the impetus for an early supersonic development program and must also be prepared to provide a major part of the financial resources for the program."

These quotations are such an accurate reflection of the present situation that their source will probably come as a considerable surprise. They are all extracted verbatim from the "National Aviation Goals" presented by the FAA Administrator, Najeeb Halaby, in September, 1961, to President J. F. Kennedy. It is a sobering thought that the fundamental problems of the aircraft industry and the airlines have remained substantially unchanged for 1-1/2 decades. In the intervening period, the nation's aerospace industry has added to its technological achievements by reaching the moon. We have introduced a new generation of subsonic widebodied aircraft into the civil transport fleets of the world, only to be faced with the same problems as Najeeb Halaby recognized in 1961, in an even more acute form than in the past.

It is imperative that the nation identify and come to grips with these problems; their solution is essential to the utilization of our most advanced technology in our civil aircraft fleets. We must ask ourselves why, having developed the quiet, fuel-conservative widebodied aircraft, we are now selling them abroad while our domestic airlines are actually reducing their widebodied fleet and reverting to the older, noisier, smaller aircraft? Why are we having such great difficulty in adopting the known technology of noise and pollution reduction as retrofits? Looking to the immediate future, we must ask whether the developments in reduced fuel consumption and conservation upon which our industry and NASA are now working will present similar difficulties in adoption after the R&D work is completed. These are topical questions, but they are currently evidence that the same fundamental problems which gave Najeeb Halaby great concern in 1961 are still plaguing us. I attribute them, at least in part, to some misconceptions on the nature of technological progress in the aviation world, which I can perhaps illuminate by making two assertions:

1. The advancement of technology requires much more than R&D.

The airplane industry obtains a significant (but declining) fraction of its basic technical know-how from military

programs, and a major input from the NASA aeronautical centers. It adds its own industrial R&D to demonstrate the feasibility of a new technical advance. Between this point and the adoption of the technology, either on a new aircraft or as a retrofit, there are a number of hurdles which require much larger expenditures of effort than the R&D process itself. These include the mundane but vitally important "qualification" programs which demonstrate the performance and safety of the new concept over all of the wide variety of conditions, operational and environmental, which may be encountered in civil airline practice.

Incorporation of the concept in a specific design is then followed by a certification program to satisfy the manufacturer, the FAA and the customer on the airworthiness of the device. This also entails additional costs; the recent increase in legal activity against the airlines has had the result that even after certification by the FAA, a novel feature may be regarded as undesirable simply because it is new and different. Additional effort and expenditure may therefore be required to underpin customer confidence.

The aeronautical world currently has a number of new technologies going through this process. A very important one is the use of composite materials in the primary structural components of the aircraft of the future. This advance is estimated to offer more improvement in fuel consumption, by reducing weight, than any other single concept which has been proposed for the fuel-conservative aircraft. The R&D work which establishes the feasibility of high-strength composites has been going on for almost a decade; we are now tackling the problems of qualification and customer acceptance. This step is difficult and expensive, but it must be done to reap the benefits of the R&D work. The members of your Subcommittee would perform a valuable service by examining this process in detail, with particular emphasis on the role of the Government and NASA in the earlier phases of the total development. The length of time from initiation to final application might be considerably shortened by extending the Government's activity (presumably NASA) further downstream into the demonstration and qualification phases.

2. New technology is not free.

Undoubtedly the chief obstacle to the adoption of new and desirable technology lies in the expense of the total program outlined above. Although it may offer major downstream benefits to the airline, it is financially "front-loaded;" it is the nature of almost all technological improvement to require a short-term investment in anticipation of much larger long-term gains. It was evident in 1961, and it is still more evident today, that the financial rules and regulations under which the aircraft industry and the airlines conduct their business are completely inadequate to permit the smooth introduction of new technologies having these financial characteristics. They have therefore attempted to carry the front-end costs on their own resources. As the quotes on Page 4 indicate, this was not successful in 1960, and its repetition in the 1970's has had even more dire consequences. It has required massive bank borrowings and sacrifice in the financial stability of the industry, while its gamblers look forward to eventual payoff from the technologies which have been introduced in the wide-bodied transports.

In debating the difficult question of carrying the front-end investment in technology, I believe that the Committee should specifically examine the two most probable candidates for the next technological advance. I would put these in order of priority as follows:

- a. The fuel-conservative subsonic transport aircraft.
- b. The advanced supersonic transport.

The aircraft industry and NASA have identified a number of advances which together could provide a next generation of subsonic transport aircraft offering as much as 30-50% reduction in fuel consumption. Some of these improvements may provide early gains by retrofit to the present wide-bodied aircraft. The technical program necessary to accomplish these gains is becoming clear, and it is also evident that the ultimate profitability to the airlines as a result of fuel savings will be many times the development cost. Nevertheless, there remains the hurdle of providing the initial investment to develop, demonstrate and qualify the improvements. It appears at the present time that, in spite of the major long-term gains, neither the airlines

nor the aircraft industry will find it easy to provide the capital necessary for this initial investment. It is imperative that we change the economic rules under which the regulated airlines operate to permit such wise investment to be made without endangering the stability of both the airlines and the airplane industry.

The supersonic transport presents a more difficult but less urgent problem than the fuel-conservative subsonic aircraft. The Concorde and the Russian TU-144 have survived the front-end financial problem and their sponsors now debate how long it would take (if ever) to recoup the investment. The deficiencies of the Concorde have been well publicized (it is nevertheless an outstanding technical achievement) and technological advances on both sides of the Atlantic promise to mitigate most of them on the next generation of supersonic transport. Engine developments which provide acceptable levels of airfield noise and upper atmosphere NO_x can now be envisaged, although the sonic boom problem still defies solution. The overall value to the airlines of a supersonic transport, linked with the question of passenger acceptance, is still in doubt, and the present fleet operations will probably give an equivocal answer to this question.

It is generally accepted that a next-generation advanced supersonic transport must have much increased range to satisfy the airline and the traveler; this requirement, together with the threat of further increase in petroleum prices, has focused attention on hydrogen as a preferred fuel for an advanced supersonic transport. All these investigations are currently in their R&D phase, and represent a very modest expenditure; the real financial problem, which I personally regard as far more difficult than the technical problems, will appear when the decision is made that the technology is ready, and our industry appears to be losing too much ground relative to our international competitors. When this occurs, the problem of making the necessary front-end investment will be much more serious than for the fuel-conservative aircraft. The technological innovations to be demonstrated and qualified will take the total development costs well outside the range that any aircraft company can prudently handle with its own resources. As our earlier quotations show, this fact was recognized by the FAA Administrator as early as 1961 when the first American SST was being discussed. The problem has only become more acute with the passage of fifteen years.

In studies of the future of aviation, the V/STOL aircraft for civil short-haul and city-center operations is frequently included as a candidate for the technology advances of the future. You will note that it was in fact included by Najeeb Halaby in 1961 in his "National Aviation Goals." In the intervening years there have been a number of attempts to develop such a system, and Canadian and European aircraft manufacturers have built aircraft which could satisfy the demand. These attempts have shown clearly that civil V/STOL operations are at best marginal from an airline economic viewpoint, so that massive subsidies will be required to make them healthy. The increased fuel prices, and the fact that V/STOL performance requires additional fuel, suggest that such operations will be even more difficult to sustain in the future. Fortunately, there is strong military interest in V/STOL for Navy operations, and also an AMST program for STOL aircraft development in the Air Force. In this manner the technology will be developed through the military route, and will be available if and when the civil market develops. For this reason, I have not included it in problem areas for which urgent Committee action is desired.

Final Summary

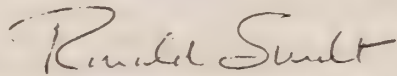
I hope that the discussion and abstracts above have served to bring out the following points:

1. The problems of the airplane and airline industries are not of recent origin; they existed in much the same form fifteen years ago, and have only grown more acute with time.
2. In large part they are associated with the nature of the process of introduction of any new technology. The R&D phase, currently receiving significant support from the U.S. Government through NASA, is only a small fraction of this total process; the larger part has been provided by the aircraft and airline industries at considerable financial risk. The unhappy financial consequences of this are such that it may be necessary, in future technical advances, for the Government to share the risk of development downstream of the R&D process itself.
3. New technology is front-loaded, requiring a short-term investment in anticipation of much larger long-term gains. The financial rules and regulations under which the aircraft industry and the airlines conduct their business

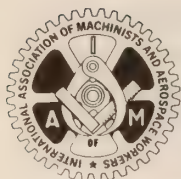
are completely inadequate to handle the introduction of new technologies with these financial characteristics. The Committee could most profitably examine this problem by reviewing the two most probable candidates for technological advances in the near future. In order of priority these are (a) the fuel-conservative subsonic transport aircraft, and (b) the advanced supersonic transport.

The fact that these problems have persisted in the industry for such a long time implies that they are deep-seated, and the Committee is dealing with some very difficult issues. I hope that the discussion above will furnish some thoughts for the Committee members, and I would be very glad to enlarge on any of my comments as required.

Sincerely,

A handwritten signature in dark ink, appearing to read "R. Smelt". The signature is fluid and cursive, with a large initial "R" and a stylized "S".

R. SMELT



**INTERNATIONAL ASSOCIATION of MACHINISTS
and AEROSPACE WORKERS**

MACHINISTS BUILDING, 1300 CONNECTICUT AVENUE, WASHINGTON, D. C. 20036

Office of the
INTERNATIONAL PRESIDENT
(Floyd E. Smith)

49-Aircraft
May 10, 1976

Area Code 202
785-2525

Congressman Dale Milford
Committee on Science and Technology
U.S. House of Representatives
Suite 2321
Rayburn House Office Building
Washington, D. C. 20515

Dear Congressman Milford:

This is in reply to your letter of April 19, 1976, in which you requested the International Association of Machinists and Aerospace Workers (IAM) to participate in an examination of the future of the aviation industry and the development of a national civil aviation research and development (R&D) policy that will sustain the aviation industry into the next century.

As a trade union representing over 250,000 workers in the aerospace and air transport industry, we are certainly concerned with the outlook for these industries as well as the broader subject of a national transportation policy. Due to time considerations, however, I cannot respond in detail to all of the important points raised in the suggested outline. Instead, I would like to respond, as suggested in your letter, to the specific issue of R&D funding in the United States and its impact on the aviation industry.

The United States' economic preeminence in the world has had as one of its main bases the nation's leadership in technology. The principal reason why many nations seek U.S. gas turbines, nuclear power systems and jet engines is simply that they are the world's best. The future economic health of the U.S. depends on a vigorous research and development effort and the product leadership that flows from it.

But many share the deep concern of the technical community that the U.S. technological lead is eroding. Other industrial nations have learned the lesson the U.S. has tended to forget: that international competitiveness depends on technological innovation and industrial know-how.

A recent Department of Commerce study points out that "the United States is perhaps the only advanced nation in the free world which has not undertaken national programs to stimulate technology development in the civilian sector." The study also notes that other governments not only fund industrial research but also provide tax incentives, interest-free loans and grants to stimulate the development and worldwide marketing of innovative products.

American industry has indicated its awareness of these problems by increasing its own funding of R&D. Yet with all its enormous growth, the federal government has slackened its participation in this critical area. Government-funded R&D in the U.S. has declined from 1.9% of the GNP in 1965 to only 1.2% in 1974. In real dollars, this has meant a 16% decrease over the past decade, substantially weakening the creative government/industry/university partnership of the 1950s and '60s.

Meanwhile, such major international competitors as Japan and West Germany have significantly increased their R&D over the past decade in terms of real effort, percentage of GNP spent on R&D, and government support of this work.

These free world nations are generally focusing R&D effort in areas which offer economic and trade growth or social welfare gain. In the face of such measures by other nations the U.S. should consider increasing its selectivity and specialization, to the extent possible, while maintaining its broad front approach to R&D. The U.S. may find it advantageous to concentrate more funding in areas where its present competitive trade leadership is threatened and in selected new technologies - for example, environment control, transportation, pollution control, or water desalination - which offer opportunities for leadership and expanded trade potential. While the relationship of science policy to economic policy can be characterized as complex and unclear, the critical role of research and development in maintaining a strong trade position in technology intensive products has been recognized. Obviously, other major factors such as capital resources, fiscal policy, the quality of management, labor cost, and anti-trust policies also come into play.

It is clear that U.S. leadership in both technology and in world trade is being challenged and the nation could lose its top ranking in both areas during the seventies. The primary reason is diminishing U.S. Government support of research and development at a time when the governments of other nations are accelerating efforts toward specific scientific and technological goals. In world trade, the U.S. is being challenged by the nations of Western Europe and Japan, who are conducting strong economically-motivated R&D programs, particularly in certain research-intensive industries such as aerospace and electronics.

One of the more direct challenges from abroad is in aerospace. An area of especially serious potential impact is the world civil aircraft market. Estimated world sales volume of airline transports is \$150 billion in the 1970-1985 time frame and \$200 billion or more by 1990. Western European industries are taking hard aim at a greater share of this market and even minor inroads would be a severe blow to a U.S. aerospace industry which has experienced crushing reverses in recent years.

The U.S. is currently supplying about 80 percent of the world market for civil aircraft, while the European nations combined account for only 16 percent. One important factor in traditional U.S. dominance in this area has been the vastly greater U.S. domestic market which is a basic foundation for longer production runs, hence lower unit costs. Another factor has been the U.S. ability to provide high levels of developmental investment. A third has been the wide variety of aircraft

types offered by the U.S. The Western European nations are seeking to counter these U.S. advantages by greater employment of the international cooperation approach to R&D. Such an approach permits engagement in high cost R&D projects which would be beyond the means of an individual nation but which become feasible when costs are shared by a number of nations. The market for the end product is broadened by virtue of multi-national requirements and the decreased financing burden to the individual nation permits a wider variety of product developments.

It is Europe in combine, rather than the U.S., which boasts the more extensive range of aircraft offerings for the future. The potential of the threat to American civil aircraft market dominance is exemplified by the commercial supersonic transport: the U.S. abdicated the market and created thereby an estimated trade balance swing of \$17.5 billion. Additionally, Western European firms are developing several other types of aircraft for which no American counterpart exists and their challenge must be considered a real one.

One cannot understate the important role technology plays in maintaining the dynamic viability of the U.S. economy: its contribution to our international trade balances, its potential for increasing national productivity and economic growth, and its capacity to generate employment opportunities. It seems clear that existing policies and coordinating mechanisms are not recognizing or adjusting on a timely basis to the present adverse trends and that new direction and increased emphasis will be required to reverse them.

The long leadtimes associated with R&D in moving from concept to practical application demand immediate policy attention to reversing existing trends in the areas of challenge vital to U.S. productivity, economic strength and world leadership position. Among the elements which should be included in any new national R&D policy should be the following:

- Establishment of an independent government financial organization such as a "national technology bank" which would provide the private sector with financial aid, either through guarantees or direct loans, for the purpose of stimulating additional private investment in R&D for both public and private programs of national and international importance to the U.S. Innovations and technology resulting from this federally sponsored R&D should be considered part of the public domain;
- Examination of the nation's antitrust laws and their administration to determine whether revisions should be effected to stimulate R&D.
- Development of innovative government/industry relationships in high-cost, high-risk technological products having high economic return for the nation;

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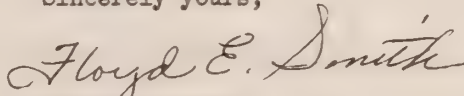
- Intensification of efforts to eliminate tariff and non-tariff trade barriers;
- Insuring that adequate financing at rates competitive with those offered by other nations is available for both civil and military exports; and progressive liberalization of trade practices and enhancement of the exporting environment, keeping in mind the need to protect both American industry and the jobs of American workers from export overseas.

In conclusion, the IAM believes that: Revitalization of civilian research and development merits incentives not unlike those recommended for improving capital formation in the U.S.; Stimulation of R&D offers the opportunity for a redirection of government spending toward more productive ends; Greater industry-government cooperation is needed most in those high-technology sectors where the scale and uncertainty of development costs, and the long time-cycles required before these costs can be recovered, make it difficult for individual companies alone to finance the essential R&D.

The creative national teamwork that waned after putting men on the moon needs urgently to be rekindled and redirected toward strengthening the U.S. in productivity, innovation and international competitiveness.

With best wishes, I am

Sincerely yours,



Floyd E. Smith
INTERNATIONAL PRESIDENT

S/lin

Dr. H. Guyford Stever
Director, National Science Foundation

Future of Aviation:
Considerations Affecting the Government Role in Aeronautical R&D

by

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Representatives

Biographical Sketches

Dr. H. Guyford Stever is the Director of the National Science Foundation and Science Advisor to the President. As an aeronautical engineer he has had a long and intimate professional interest and involvement in aviation. Dr. Dennis Schiffel and Dr. Alden Bean are Senior Policy Analysts in the National Science Foundation's Policy Research and Analysis division. Dr. Schiffel has degrees in both economics and law while Dr. Bean has specialized in industrial engineering and organization theory. Both Dr. Bean and Dr. Schiffel are involved with research on technological innovation and science policy.

Summary

The question addressed in this paper is the appropriate role of government in aeronautical research and development (R&D). To define that role the paper suggests that it is necessary (1) to understand the institutional structure of the aviation industry, (2) to understand some characteristics of aeronautical R&D, (3) to identify aviation policy issues which may confront the Federal Government, and (4) to have some economic criteria or guidelines which apply to potential investments in aeronautical R&D. Neither economic criteria alone nor general policy issues in isolation will provide adequate definition of the appropriate government role in aeronautical R&D.

The authors suggest that recent trends in military aeronautical R&D and in the commercial fortunes of aerospace manufacturers and airlines may portend a decreasing level of commercially oriented or commercially adaptable aeronautical research. Some potential policy issues are raised, relating to foreign competition, financing of R&D, and the market size/production volume characteristics of aircraft development and production, which may affect government's role in aeronautical R&D.

Future of Aviation:

Considerations Affecting the Government Role in Aeronautical R&D

I. Introduction

Aeronautical R&D has contributed to the worldwide prominence of the U.S. aviation industry and has helped provide us with an exemplary air transportation system. The industry has, however, been under considerable economic pressure in the past several years. This pressure raises anew policy issues which must be dealt with in order to define the role of government and formulate government policy toward aeronautical R&D.

Any serious discussion on the Future of Aviation raises questions concerning the appropriate government role in aeronautical R&D and aviation innovation--questions which arise frequently in policy debates concerning innovation and R&D. This paper will address the issue of appropriateness first by sketching some criteria that apply generally to government investments, including R&D. Second, some particular characteristics of the aviation sector will be identified and their implications for the appropriateness of government supported aeronautical R&D noted. Third, a general sketch of the aviation sector will be provided. And, fourth, in the context of these latter two sections, some current policy issues facing aviation and aeronautical R&D policy-makers will be raised. The main purpose of this paper is to raise criteria and issues deserving more in depth examination.

II. General Criteria

Three primary criteria should be considered in assessing potential government investments that are not designed as income transfer or welfare programs:

1. The benefits to society of a federal investment exceed the costs imposed on society by that investment.
2. The net benefits or net return from the investment is at least as great as the net benefits from alternative investments the government could make.
3. There is inadequate incentive for industry to undertake the proposed investment if government does not.

These criteria are based on notions of efficiency with which most people would agree. That is, government should invest society's resources in areas which have the highest payoffs to society. There are, however, cases where it is difficult to project in a quantitative fashion a future benefit to society, and there have been cases where the Federal Government has made investments in the country's future where no payoffs were expected in the foreseeable future but where long-range, unexpected benefits have accrued. While historically these have been exemplified mainly in such investments as land purchases--the Louisiana Purchase and the Alaska Purchase--there have been unexpected benefits from investments in technologies in the military, nuclear, and space fields that may eventually far exceed any conceived of originally. Most Federal investments in R&D today, however, even those dealing with long-range energy programs, are predicated on an economic payoff, even if it is 25 to 50 years hence.

Although the foregoing criteria can be stated much more technically and in more detail, they serve as an initial or screening set of criteria for government investment in applied aeronautical R&D¹. In theory these criteria also apply to investments in basic aeronautical R&D research, but the great uncertainty about the knowledge that will flow from basic research in aeronautical R&D limits their applicability in practice though not their conceptual usefulness. In fact, the major debates over technological innovation and aeronautical R&D will probably not be debates over these generally accepted criteria but rather over whether social benefits exceed social costs or whether industry will or should invest in particular aeronautical R&D programs. The next section provides a perspective on this latter issue.

III. Characteristics Related to Appropriateness of Government Investment

Questions as to whether a particular investment, whether made by government or industry, will yield benefits in excess of costs depend upon a host of factors associated with each potential project. However, a key issue in public policy debates over government aeronautical R&D expenditures, and government investments in general, is whether it is appropriate for government or industry to fund the investment. That is, assuming the expected benefits exceed the expected costs, who should pay for the R&D and investment?

The mere expectation of social benefits from an activity, i.e., benefits accruing to the general public that a private firm cannot capture, does not mean government investment is appropriate. Indeed, uncaptured social benefits (and costs) arise from many private activities. The real measure of appropriateness of government investment vis-a-vis industry investment in R&D is whether there are insufficient incentives to attract industry investment, assuming the investment is socially worthwhile. Below, some considerations or characteristics of R&D are discussed which affect the appropriateness of the government vs. industry support of R&D. These characteristics are:

1. Technological uncertainty about the success of R&D programs.
2. Market uncertainty about the saleability of products embodying R&D results.
3. Public goods or benefits stemming from R&D which a private firm cannot capture (inappropriability).

Technological Uncertainty

To the extent that emerging aircraft technology departs from tested and proven techniques and the increases sought in technological capability rise, civil aeronautical R&D becomes increasingly risky. For example there is always the prospect that certain technological advances required to operationalize a new aircraft design (1) may never be made or (2) may turn out to be excessively costly because of technical problems.

The existence of these two types of technological uncertainties or risks may cause the businessman to incorrectly estimate expected costs and the likelihood of technical success. Given the inability to correctly or objectively assess risk-uncertainty and hence expected costs, the risk-averse business man might be expected to undertake less R&D than otherwise for a fixed level of benefits likely to flow from a successful R&D and consequent production program. Thus, in the absence of government investment there would likely not be investments in R&D in areas of high technological risk--particularly where the costs of R&D are high.

Market Uncertainty

Even if commercial aviation R&D is successful in a technological sense, the private company may be unable to capitalize on it. The Concorde is a technological success but its potential commercial success is currently being tested. It is costly to buy and costly to operate in comparison with alternative aircraft now in use. Whether Concorde's high speed will offset the resulting high fares in passengers' minds is an open

question. Moreover, the Concorde has a relatively short range and is prohibited from flying at supersonic speed over populated areas (most land areas) because of potential sonic boom damage and annoyance. While these are potentially remediable problems, eliminating sonic boom is a much more fundamental and difficult research problem than extending the Concorde's range or building a more cost effective SST. The Concorde illustrates the interplay between technical advance and market factors in commercial aviation.

The market uncertainty issue is also reflected in recent debate over whether industry or government should build an aeropropulsion system test facility (ASTF). Both the net benefits and the incentive of industry to build the facility are subject to "market" factors beyond their control. The net benefits and private profitability of the ASTF depend on how many new commercial engine families and new military engine families will be developed in the next 25 years.² The latter is a government decision beyond the manufacturers control and the former is a decision in which the airlines will play a role, i.e., how many new aircraft engines will the commercial market demand. If industry builds the facility and too few new commercial and military engine families are built, the U.S. civil aircraft manufacturing industry's costs (relative to foreign competitors) will rise because of the need to amortize the facility over fewer new engine families.

Appropriability of Benefits and the Basic Research Distinction

Another reason for government involvement in the aeronautical R&D arena is the existence of noncapturable benefits stemming from aeronautical R&D. That is, the developer of new aeronautical technology may believe he will not be able to capture sufficient benefits, even though the net benefits are large, to make it

worthwhile for him to invest in the necessary R&D in the first place. On these appropriability grounds, as R&D becomes more applied and developmental the appropriateness of government involvement usually declines. And, as research becomes more basic, government involvement becomes increasingly appropriate.

To illustrate, a manufacturer who funds research leading to advances in the basic understanding of supersonic flight may capture little benefit, or gain little differential advantage, over his competitors. Hence he is unlikely to fund such aeronautical R&D out of his own resources. On the other hand, the developer of a patentable quiet engine or engine quieting retrofit package may expect significant commercial rewards because (1) he will be able via his patent to exclude other manufacturers from sharing the rewards from applied R&D and (2) congressional and public concern with engine noise "guarantee" commercial sales if current noise standards are enforced.³

On conceptual grounds then, government involvement in aeronautical R&D is most appropriate when the outcomes of R&D are uncertain in technical or market terms but a priori large social benefits might be expected to emerge. This is the case with the space shuttle. The shuttle in itself is largely an engineering achievement at this point in time, although it obviously rests on much prior basic research. However, the expected benefits of the shuttle are, in part, in terms of new medical, biological and physical science research it will permit in space. The expected benefits from such research in space are potentially significant but speculative.

Summarizing this section, a series of questions, based on the above discussion, can be asked with respect to all government investments in R&D:

1. Are incentives for private industry to invest in particular R&D projects inadequate?
2. Do substantial benefits exist which are non-capturable by any one private firm doing R&D?
3. Are there substantial social benefits (i.e. benefits not capturable by the firm which accrue to the public at large) which would more than offset the costs that government and industry might incur in conducting the R&D in question?
4. Do these social benefits exceed those that might flow from other R&D projects?
5. Is the project basic research?
6. Is there a long time horizon for research and development before any returns will be obtained from the investments in R&D?
7. Are technical risks associated with the R&D high?
8. Is the new technology being developed unlikely to be marketable at a profit?⁴

While some of these questions overlap, if the majority (particularly 1, 3 and 4) are answered affirmatively then government involvement seems appropriate. A similar set of technically oriented questions should also be answered in the affirmative before government involvement is appropriate.⁵ However, since these questions go to the quality and technical necessity of the proposed R&D they are best handled by the judgement of technical experts in the particular field of R&D. The burden on these experts is to not only judge the technical merit and feasibility of the proposed R&D but also to translate the expected

outcomes into terms public policy-makers can understand and utilize in making the judgements associated with the list of questions above. For example, the technical experts might suggest which technologies or which R&D programs might have the highest potential payoff in terms of advancing the knowledge base of aviation technology. Or they might suggest which research is most appropriate in terms of solving short- and long-term technical problems in the aviation field, as well as indicating what potential benefits will flow from particular types of R&D.

IV. Institutional Considerations

While the preceding discussion provides conceptual and practical guidelines to the appropriateness of government involvement with respect to aeronautical R&D projects, it is important that certain institutional facts and issues, which modify these guidelines, not be overlooked. It is perhaps most important to distinguish aeronautical R&D oriented toward the commercial aviation market from aeronautical R&D oriented toward the primarily government space exploration, space technology and military aircraft "markets."

In the commercial aviation market, the demand of the commercial airlines for new flight equipment must be carefully integrated into aeronautical R&D planning. The benefits of new technological developments may be long delayed if the airlines are either unwilling or unable to buy new flight equipment. The recent financial problems of the airlines resulting from low passenger traffic growth and increasing costs, particularly fuel costs, limit their ability to purchase new aircraft or engines embodying the latest technology. On the other hand, many of the airlines have first generation jet aircraft nearing the end of their useful lives. New equipment will be needed and the appropriate R&D for the commercial market is probably oriented toward cost saving and environmentally acceptable technologies, i.e., technological improvements in aircraft materials to reduce weight and hence fuel consumption, improvements in engine fuel efficiency and noise output, improvements in airframe design to reduce drag and hence fuel consumption, improvements in airframe and engine to reduce maintenance expenses and so forth.

In addition to integrating aeronautical R&D planning with the demand for new commercial aircraft and airline reflecting schedules, aeronautical R&D must be planned in light of future military and space exploration technology needs. In general the government through NACA, now NASA, and the Department of Defense has funded a large part of aeronautical research.⁶ The aerospace manufacturers in conjunction with the airlines have supported the development of technically advanced commercial aircraft, drawing on technology developed by NASA and DOD. Now, however, given current military objectives such as dash aircraft, military supported R&D may be becoming less immediately relevant and transferable to commercial transport development. This may increase the cost of doing commercial aircraft technology development for the manufacturers. The possible impact of changing military aviation needs and aeronautical R&D on the commercial aviation industry illustrates the need to foster integrated aeronautical R&D planning within the context of both military and civil aviation.

The civil aviation industry today consists of a relatively small number of large, highly specialized public and private organizations, whose collective activities are important and highly visible in terms of goods and services produced and of resources consumed. The fact that the industry is highly specialized and involves complex relations and functions, which have become institutionalized through laws, programs, and regulations, has significance for policy-making.

Effective policy development related to this industry requires some specialized knowledge about how the industry is structured, how

the various functions necessary for technical and commercial success are performed and by whom, and how various incentive mechanisms affect the efficiency and effectiveness with which these functions are performed. The discussion which follows presents several of the key institutional features of this industry together with a brief historical explanation as to how these relationships came about.

The integration of aeronautical R&D planning with the demand for new commercial aircraft and coordination with airline refueling schedules was suggested above as a means of fostering efficient use of public and private resources for civil aviation. The concept, however, is difficult to achieve because of the institutional complexity and specialization of the industry. Additionally, the market for air transportation may be shifting in composition and rate of growth, raising the possibility that the industry's performance in past years may not be a realistic guide to the future.⁷

The most significant opportunity to introduce advanced technologies into commercial aircraft occurs when new generations of transport aircraft are "launched." Historically, this occurred about once every 8 to 10 years.⁸ The impetus for launching new aircraft came from exogenous technical change which improved aircraft operating characteristics, negotiations between airframe manufacturers and airlines based on airline executive expectations of growth in demand, and changes in route structure and competitive conditions which made existing airline fleets less than optimal. The placement of orders and advance payments to the manufacturers against these orders paved the way for the design/development work and retooling needed to introduce new aircraft. The technology

incorporated into such designs often was "state-of-the-art" technology which had been proven in military aircraft, particularly military transports, designed and built under government contract. In addition to the advanced aeronautical R&D carried out by commercial manufacturers for the government, the Federal government has invested heavily in its own R&D facilities. Thus, as a supplement to DOD sponsorship of aeronautical R&D, aeronautical research has been carried out in NACA and NASA facilities since the early days of aviation.

Thus the coupling between aeronautical R&D and the market for commercial aircraft is not direct. The functions performed by the firms and agencies in the industry are highly specialized. Operating airlines do virtually no major technological development work, although they may provide the impetus for such work through their role as launching (initial) purchasers. Similarly, the development and testing of "hardware" versions of new aircraft is done primarily by airframe manufacturers, especially since the decline in overlap between military and civilian transport programs. A major portion of the basic R&D relating to aviation technology, including that R&D incorporated in air transports, is done by government laboratories or under government contract. Consequently, changes in market trends or competitive conditions may not bring about automatic adjustments in aeronautical R&D, but may require conscious cooperation on the part of government and industry.

Within the past 5 to 8 years, growth in demand for passenger air travel has moderated, with cargo transportation growing at a somewhat higher rate than passenger traffic growth. Airlines which had purchased aircraft in anticipation of increases in passenger travel growth found themselves with excess capacity and heavy financial commitments. A declining growth in demand for passenger air travel coupled with the existing financial plight of air carriers suggests that the lag between generations of aircraft may stretch out beyond 10 years in the future. Thus the implementation of major systems advances, such as the extensive use of composites in structural members, the use of supercritical air-foil construction, and the application of area-rules to fuselage construction might be delayed for some time.

If growth in demand has leveled off and the refueling cycle lengthens as a result, it appears likely that the incentives acting upon the airframe manufacturers to invest in R&D for major advances are declining relative to the incentives for incremental improvements, such as those which could be implemented through retrofit programs or through minor modifications to existing production tooling.

This possibility is confounded by certain economic and physical constraints recently encountered by operating airlines which not only affect their current and future operating costs, but which change the relative importance of existing R&D programs conducted by both industry and government. For example, airport congestion and air-traffic control problems have increased the attractiveness of wide-body aircraft designs which can accommodate more passengers, thus

reducing frequencies of arrivals and departures on certain route segments. Additionally, supercritical technology has become more attractive with rising fuel costs. Earlier, supercritical technology was discussed in terms of (and perhaps even stimulated by) a perceived need for a means of flying closer to mach 1 without paying a penalty in terms of "drag" on the airfoil. While it does accomplish this, it also reduces drag at lower speeds, thus permitting increased fuel economy or payload increases at subsonic speeds. Thus, in this case, we have a technology which probably cannot be introduced until the airlines refleet, but which offers opportunities for immediate savings in operating costs. Such cases demonstrate how the complex institutional structure of this industry and the economics of air transportation are linked in many ways to R&D programs. Such cases also demonstrate that a stretch-out in the refleet cycle increases the amount of time available to create and develop major technological innovations for new generations of aircraft. However, it also increases the amount of time required to realize a financial payoff from the R&D investment. Under the conditions faced by the industry today, private airframe manufacturers are not likely to respond to a stretch-out by increasing their investment in major R&D programs. Thus these conditions suggest that some cost-saving technologies for the next generation of medium and long haul transport aircraft may be foregone unless Federal R&D programs are continued or enhanced.

V. An Outline of Some Policy Issues

While the predominant theme of the preceding pages is the identification of criteria, particularly economic criteria, for government investment in aeronautical R&D, and a sketch of institutional features of the aviation industry, a number of other policy issues will also confront government in the future. Brief sketches of some of these issues are provided below.

Public Service Feature of Aerospace Industry

Traditionally, economic regulation has been applied to industries which are characterized by declining unit costs as output increases. That is, because of economies of scale, one producer is able to produce, say electricity, cheaper than two or more producers in the same market area. It is the economics of available production technology and the size of the market that determine whether a regulated monopoly would be the lowest cost producer.

Recent trends in the aviation business may be pushing us toward a similar situation with respect to the large domestic civil aviation manufacturers. As development and production costs have risen, each producer must sell more aircraft to be able to amortize development costs over sufficient production volumes to make them cost effective. Similarly, the nature of learning curves in aircraft production is such that the 200-th plane manufactured of a given model usually costs substantially less than the first manufactured aircraft of the given model.⁹

In 1953, John McDonald writing in Fortune said:

It is clear, that all three builders cannot stay in this market; perhaps not even two can make money on jets in the next ten years. The first question is which of the three, Douglas, Lockheed, or Boeing is going to drop out.

Subsequently, Douglas merged with McDonnell and Lockheed effectively left the commercial airline business in the late 1950's. Lockheed, of course, has attempted a major reentry in the commercial field with the L-1011.

Whether Lockheed will be successful with (a) the L-1011 program or (b) reestablishing itself as a larger term competitor in the civil aircraft business remains to be seen. However, McDonald was correct in his prediction for a time. His prediction is now being echoed in the 1970's by various aviation leaders who contend there is not enough of a market to support the current number of airframe manufacturers in the business.¹⁰ This is a potentially serious problem because it suggests that total aircraft production costs to society are higher than necessary in comparison to a situation with fewer competing aircraft. On the other hand, airlines under the current competitive system get the benefits of price and delivery concessions from the manufacturers. The policy issues that arise with this market size/production volume issue include:

- ° the government's posture toward limited or decreasing competition in commercial aircraft manufacturing;
- ° the role the government might play in allocating or regulating commercial market activities of the manufacturers in order to make U.S. aircraft more cost competitive through longer production runs by one manufacturer and reduced development costs;
- ° the integration of military preparedness needs with the commercial applications of aviation technology by the large aerospace manufacturers;

- ° the implications of possible changes in the airframe manufacturing industry and/or federal policy for R&D policies; and,
- ° what institutions (government, industry) should assume responsibility for supporting and conducting R&D programs and development work to assure cost effective technological progress coordinated with airline reflecting

Balance of Payments and Foreign Competition

One of the arguments often made in conjunction with government support of aeronautical R&D relates to the balance of payments effects of aircraft sales abroad and foreign competition. However, the balance of payments argument is not as obvious as it might seem. Let us restate the argument. On the one hand, balance of payments effects of selling aircraft abroad are not a justification for government involvement in civil aeronautical R&D. First, technological superiority from R&D is not the only ingredient in commercial success, i.e., future sales as a result of aeronautical R&D are unpredictable. Second, there may be better and more direct ways to alleviate balance of payments problems than through aeronautical R&D. Third, R&D subsidy to any other industry could also produce a balance of payment effect similar to that stemming from federal support of civilian aeronautical R&D. Fourth, the argument for aeronautical R&D on balance of payment grounds becomes weakened when, and if, the balance of payments becomes positive. On the other hand, having established a world wide reputation, a world wide marketing and distribution network and a high level of technical and market competence in the development and sale of aircraft, it would be difficult for the government to stimulate, with the same amount of investment, another industry to have as favorable an effect on our balance of payments as the aviation industry. That is,

the balance of payments benefit of aeronautical R&D expenditures of the federal government are the balance of payments effects that result from an incremental change in federal aeronautical R&D support as opposed to a similar change in support of some other types of R&D. Even so, if history is a guide, to maintain this balance of payments effect does not require that U.S. manufacturers be the first to introduce new technology equipment, but rather to be the first to introduce new technology in a cost effective manner. For example, the British Comet was the first commercial jetliner but it was quickly eclipsed commercially by the Boeing 707 and DC-8. Although the AC300B represents a competitive inroad, DC-10 and L-1011 twin engine derivatives may become the commercially superior aircraft in the class.

The more important aspect of the AC300B, and the Concorde, is that they clearly underscore increasing European cooperation in commercial aviation. Such cooperation, with foreign government support, could increase technological competition for American manufacturers, particularly since foreign governments may wish to break what they perceive as the American commercial transport monopoly--by value the U.S. has provided over 90% of the free world commercial aircraft in service. What position the U.S. government should take in assisting U.S. manufacturers in any R&D competition will depend upon diplomatic and military factors as well as economic factors. A necessary input to the determination of that policy position is information about how the aviation industry as a whole will adapt to shifting patterns and levels of world demands for air transportation in view of the increased interest of foreign manufacturers and governments in penetrating the commercial aircraft market. Another policy issue which will need to be resolved is the federal government's

position toward increased international cooperation ventures by American manufacturers. For example, SNECMA and G.E. have worked cooperatively in engine development and the airframe manufacturers are looking into the possibility of launching cooperative ventures with foreign manufacturers.

Alternative Financing Arrangements

Traditionally the development of new commercial aircraft has been financed by the aircraft manufacturers in conjunction with advance orders and advance payments by the airlines. While background research and new technologies may have emerged from prior government, particularly military, supported research, new commercial aircraft have been privately conceived and the necessary development work privately funded.

The airlines having experienced, and still experiencing, low profitability and still digesting the acquisition of widebody jets, are not in a position to give manufacturers much encouragement or support in the development of new aircraft, despite the aging of the first generation jets still in airline fleets. While the airframe manufacturers may anticipate that airlines will need new equipment in the early to mid-eighties, they must have some doubt as to how airlines would pay for new equipment. The airlines have relatively high debt to equity ratios and some major lenders have expressed reluctance to provide additional funds to the aviation industry.¹¹

The manufacturers who have yet to amortize the development and tooling costs of the wide body jets are similarly not in a position to undertake extensive research and development expenditures in support of new aircraft. In fact, given price and product competition among the aircraft manufacturers

and the seemingly inexorable escalation of development costs, the market for new airliners has not been particularly profitable for the aircraft manufacturers, even in the presence of military aeronautical research that could be and has been adapted to the commercial market.¹² How the function of prototype development and flight testing of major innovations (affecting overall systems design and performance) will be conducted in the future, given the declining overlap between military and civil transport aircraft needs and the rising costs of developing "new" aircraft (estimated at \$300,000 for the DC-3 in the 1930's and \$1 billion each for the DC-10 and L-1011) remains to be seen.

Given the presence of these conditions, the reported reluctance of some lenders to provide additional funds to the aviation industry and the foreign competition and public utility aspects of aeronautical R&D, coupled with the purported social or public benefits that result from aeronautical R&D, perhaps a new set of financing arrangements may be called-for, involving government, to finance the development of new commercial aircraft. Even if government involvement is not warranted on the basis of the economic return to society, it still may be possible to create new financing arrangements that would not involve a subsidy unless one were desired.

VI. Conclusions

This paper has suggested a set of criteria or guidelines which should be applied in determining the appropriateness of government involvement in R&D, including aeronautical R&D, and has raised policy issues that government and industry may both face with respect to aviation and aeronautical R&D. In general the policy issues are not strictly economic concerns or objectives but they are related to economic or investment criteria. That is, even if the net economic benefits are negative (costs exceed benefits) or low, other objectives related to, for example, foreign policy, international competition or the like may dictate government involvement. However, the costs of achieving these "non-economic" objectives are measured in large part by (1) the degree to which government investments in R&D depart from the economic criteria or guidelines noted above and (2) the amount by which the total rate of return on the government investment falls short of the return on other government investments. The danger for policy making lies in confusing rather than carefully separating economic and noneconomic reasons for government involvement in commercially applicable R&D.

Based on the institutional considerations noted above, it seems the government should not become involved in major system, e.g., new aircraft, design for the civilian market nor should it become involved in "pushing" technology in the civilian aircraft market. The function of introducing new aviation technology to the market has been successfully performed by private industry. However, the underlying technology has

often resulted from government-supported aeronautical R&D. With changing government needs, largely military and space, for aeronautical R&D with possibly reduced commercial adoptability and with financial constraints on the entire aviation sector, there is some question as to how commercially useful aeronautical research will be funded. While we have noted above that government involvement is less appropriate the closer technology lies to commercial application, it is useful to draw attention to the distinction between aeronautical development (of new commercial aircraft) and aeronautical research. The comparative British, French, and American experience indicates that as a factual matter government involvement in developing and commercially introducing new civilian aeronautical technology (e.g., Comet, Concorde) may produce a result inferior to private sector, market-determined decisions on which new technologies to introduce, the timing of that introduction and the characteristics of the aircraft introduced. (Alleged market failures to introduce new technology may not be failures but correct decisions in many cases.) However, the Federal Government on policy grounds may choose to assist the commercial airlines and U.S. aircraft producers in competing with foreign governments in aeronautical R&D (particularly aeronautical research), sales of aircraft, and airline operations.

It seems relatively clear that basic research in aeronautical technology will probably be inadequate from a social standpoint in the absence of government-funded aeronautical research. We cannot prove that aeronautical R&D will in fact lead to technical advances which generate net benefits; but we can with assurance say that without such government involvement less aeronautical research will be performed,

foreclosing the possibility of benefits. Basic research in any area almost always proceeds out of optimism, in the face of uncertainty, that the potential benefits will exceed the costs.

Footnotes

1. For an extensive technical discussion of these criteria and other considerations in government support of R&D, see, H. J. Brumm, Jr. and J. M. Hemphill, Jr., The Role of Government in the Allocation of Resources to Technological Innovation: A State of the Art Review, A report to the Office of National R&D Assessment, National Science Foundation, February 1976 and R. A. Rettig, J. D. Sorg, and H. B. Milward, Criteria for the Allocation of Resources to Research and Development: A Review of the Literature, a report to the Office of National R&D Assessment, National Science Foundation, July 1974.
2. See, The National Aeronautical Facilities Program: Issues Related to Its Cost and Need, Report to the Committee on Appropriations, House of Representatives by the Comptroller General of the United States, March 23, 1976.
3. NASA in fact supported development of quiet engines. However, this NASA engine development program was accompanied by a recoupment of Federal funds feature. Moreover, the program was undertaken in part because of the uncertainty attached to what noise regulations would be, in fact, established and enforced. In the absence of certainty about enforcement and with airlines having low profitability, it seemed the engine manufacturers lacked market incentives to push quiet engines in the short run for retro fitting aircraft, i.e., there was no assurance the airlines would be required or able to buy the engines.
4. For more in depth treatment of some of these issues, see, Noll, et al., Government Policies and Technological Innovation, A report to the Office of National R&D Assessment, June 1975.
5. For illustration of these types of questions, see, Technical Basis for a National Civil Aviation RT&D Policy, a joint AIAA/NSF conference March 10-12, 1976, report forthcoming and The Role of Technology in Commercial Aircraft Policy Formulation, a joint AIAA/NSF workshop conference, March 21, 1976.
6. In general on these and other institutional factors, see, Civil Aviation Research and Development Policy Study, a joint report to DOT-NASA, March 1971.
7. Whether the U. S. passenger air travel market is saturated is debatable, but it is true that in recent years cargo traffic has been growing relatively faster than passenger traffic and the developing nations represent potentially large new air travel markets.

8. R. Miller and D. Sawers, The Technical Development of Modern Aviation, (New York: Praeger Publishers, 1970), p. 313.
9. For an interesting application of the learning curve approach to aircraft production, see, U. E. Reinhardt, "Breakeven Analysis for Lockheed's Tristar: An Application of Financial Theory," Journal of Finance, Vol 28, No. 4, September 1973.
10. See for example "Manufacturers Watch for Traffic Upturn." Aviation Week and Space Technology, Vol 104, No. 11, March 15, 1976, p. 143.
11. See, for example, "Major Lender Unwilling to Commit More," Aviation Week and Space Technology, Vol 104, No. 18, May 3, 1976, p. 27.
12. S. L. Carroll, "The Market for Commercial Airlines," in Caves and Roberts (eds), Regulating the Product: Quality and Variety, (Cambridge, Massachusetts: Bollinger Publishing Co., 1975), pp. 145-169.

THE FUTURE OF HELICOPTER AVIATION

By T. R. Stuelpnagel
Vice President and General Manager
Hughes Helicopters

SUMMARY

The helicopter will make its next major contribution in improving the quality of life by helping solve the urban transportation problem. Small helicopters can be used to relieve urban growth by encouraging decentralization of new industry to the outer fringes of the urban area. Larger helicopters of 10 to 12-passenger size can be used as commuter transports on a 10-minute departure schedule throughout an urban area to maintain efficient urban mobility for existing businesses to prevent the exodus of jobs and tax base.

Helicopters are also contributing phenomenally to an average of 10% suppression of crime and a two to six times increase in apprehension of criminals for 1% to 3% of law enforcement budgets. This breakthrough needs more encouragement at the national level.

A civil aviation policy is required to recognize the helicopter as a necessary urban transportation vehicle by initiation of demonstration transportation programs. Consideration should be given to a means of sharing the risk with industry in developing the required transport helicopters. Assistance is needed throughout the country in heliport development and regulations. Support is needed by NASA and other agencies in R & D funding to develop quieting, flight safety and public safety application technology.

Two percent or \$1 billion of the national public transportation budget will contribute 250,000 jobs per year to urban communities nationwide, plus \$100 billion in economic base over a 20-year period.

Adoption of a plan and initiation of a demonstration program is required now to supplement rail and road development.

18 May 1976

THE FUTURE OF HELICOPTER AVIATION

By T. R. Stuelpnagel
Hughes Helicopters

The civil helicopter is now making a significant contribution in worldwide resource development but its future role will be even more significant to the quality of life by helping solve the urban transportation problem. This role has been largely overlooked by transportation planners and underrated by public agencies. In this context, the Hughes Helicopters' view of the future of helicopter aviation is presented with recommendations for an expansion of U. S. civil aviation policy to include helicopters.

I. NATIONAL TRANSPORTATION CONTEXT

The helicopter can play a vital role in the national urban transportation system to relieve and supplement surface transportation systems. It can do this in two inter-related ways. One way is to transport people directly throughout the urban area; the other way is to use the helicopter as a tool to permit greater industrial decentralization to the fringes of the urban area, thus minimizing urban travel. The payoff to the company is potentially reduced labor cost and a more stabilized work force by having their decentralized plants located in the city fringe within a radius of perhaps 50 to 100 miles. The payoff to the plant employee is the reduced transportation cost and the more favorable living conditions. The payoff to the city is the elimination of traffic flow through the city center, decreasing the need for additional roadways and rapid transit systems. The potential of this approach is evidenced by the fact that the cost of a light turbine helicopter can be offset by as few as 100 employees who would save 20 miles a day each in round trip driving to their work. A decentralized plant of 1000 employees under these conditions would save up to 250,000 gallons of fuel per year as well.

In consideration of the direct transport mode, a 10 to 12-passenger helicopter can be used as a commuter transport on a scheduled route throughout an urban area on a 10-minute departure schedule. In this size and mode, a large enough load factor could be obtained in high density areas to operate at low cost to the traveler.

The helicopter is an effective transportation vehicle for ranges up to 300 miles, and is essential to the congested megalopolitan areas of the northeast, northcentral, and southwest to support commercial development and employment. Central cities within

these areas are now experiencing serious losses in available jobs due to the departure of major businesses to the suburbs. The helicopter will aid commercial enterprise by supporting business operation throughout the megalopolitan areas.

Business operations generate seven million auto trips per day¹ or four percent of all auto trips in all standard metropolitan statistical areas (not counting employee travel to and from business). The inefficiency of urban mobility has reduced industrial productivity and has contributed to the departure of business from the central city. Therefore, it is essential that a fast, low cost, supplementary transportation mode be made available to meet the business need. The helicopter is the vehicle ready to meet the need. The helicopter will be to transportation within the cities in the next 30 years what fixed wing aircraft have been to transportation between cities in the last 30 years. These ideas are developed in more depth in the accompanying paper, "The Helicopter is a Necessary Urban Transport for the 1980's."

In public safety, a major development has occurred in the use of helicopters as a transportation vehicle which has largely gone unnoticed. As a city police patrol vehicle, the helicopter has succeeded in suppressing crime an average of 10%, doubling criminal apprehensions per call and increasing felony arrests per patrol car by as much as six times; all for only 1% to 3% of the law enforcement budget. This has been a phenomenal achievement in law enforcement productivity at a time when the national crime statistics and public concern are at an all-time high. Yet, helicopter use in law enforcement has not received proportionate recognition at the national level to capitalize on this breakthrough.

Use of the helicopter in public safety also includes emergency rescue, fire fighting, environmental control, and traffic control. These public safety applications are developed in greater depth in the accompanying paper, "The Helicopter is Coming to Town."

To achieve the full potential of the helicopter in urban use, more research and development is needed for:

- a. quieting
- b. flight safety
- c. public safety support equipment and techniques

These programs will increase public acceptance and support for utilizing the helicopter in and over urban areas on a scale suitable to benefit the communities. As an example, the R & D status of helicopter quieting is discussed in the accompanying paper, "The Coming Era of the Quiet Helicopter."

¹ "1974 National Transportation Report," Department of Transportation, Washington, D. C., July 1975

II. HELICOPTER AVIATION PROGRAM REQUIREMENTS

Helicopter aviation programs are prominently absent from the national aviation system plans and national transportation reports prepared by the government. The federal government is urged to recognize the essential role of the helicopter as one of the solutions to the urban transportation problem.

The role of the government lies with the Department of Transportation (DOT) to incorporate helicopter programs in its National Aviation System Plan establishing pilot programs for urban transportation systems with light helicopters and series of heliports. These programs should be coordinated with the National Aeronautics and Space Administration (NASA) programs for improvement of flight safety and helicopter quieting to meet the requirements of urban operation. These programs must be accompanied by industry initiative to develop the helicopters required.

III. ECONOMIC AND FINANCIAL FACTORS

To implement helicopter aviation system development, the federal, state, and local governments as well as industry must participate. Industry participation can be encouraged by the federal government establishing means for industry to borrow low interest capital where it is not available from private sources. New commercial helicopter development is very expensive, like commercial fixed wing development. The finance program must recognize the risk associated with aircraft development, and the government should be prepared to absorb some portion of the loan in the event of payback difficulties. The risks of this approach are balanced by the saleability of the technology to offset foreign trade and the contribution of the technology to U. S. defense preparedness. U. S. government encouragement of commercial helicopter development will also help to offset the support being given by foreign governments to their commercial helicopter companies.

Federal government participation may also take the form of cost sharing with state and local governments for the establishment of urban transportation systems, including the establishment of public use heliports. Regulations at present are so severe that it is almost impossible to build public heliports in our cities.

The latest Department of Transportation assessment² is that federal, state, and local governments plan to spend an average of \$3.4 billion per year through 1990 for public transportation. If only a four percent share is considered, which represents the share of auto trips generated by business, then \$136 million per year of \$48 billion could be available to help service that segment of travelers. However,

² "1974 National Transportation Report," Department of Transportation, Washington, D. C., July 1975

for only two percent of these funds or approximately \$1 billion, a helicopter transportation system could be developed for each of 25 metropolitan areas by 1990. The money would be disbursed as follows: \$500 million for ten heliports to begin with in each of 25 major metropolitan areas; \$300 million for loans to major aircraft manufacturers for helicopter development that would be paid back from helicopter sales revenue; \$100 million for air traffic control facilities; and \$100 million for personnel training, administration and general expenses. This investment will support the major economic growth in the United States that will take place in the megalopolitan areas, and contribute to the development of better than 250,000 jobs per year in the manufacturing, trade, and selected services around the 25 metropolitan areas. These jobs represent an increase in local income in excess of \$100 billion over a 20-year period from 1980 to 2000. This income will have a multiplying effect on national income as well.

Thus, an investment of \$1 billion helps to create and support an increase of \$100 billion in the 20-year economic base of the metropolitan areas at a time when there is a growing resistance to extending freeway and railroad rights-of-way that threatens to restrain economic growth.

The facts presented here warrant a recognition of helicopters as a necessary urban transport and the need for an immediate effort to invest money in the initiation of an experimental operation in a selected location. This will permit the early evaluation of the system to establish the costs and operating requirements for national implementation.

The necessity for a helicopter transportation system for urban application is the key to the growth of employment and economic viability of the developing urban communities. A helicopter transportation system must be regarded as a necessary supplement to rail and road development.

***The Helicopter is a
Necessary Urban Transport
for the 1980's***

Thomas R. Stuelpnagel
Vice President and General Manager
Hughes Helicopter Company

THE HELICOPTER IS A NECESSARY URBAN TRANSPORT
FOR THE 1980's

It is well known that the economic growth of an urban community is dependent upon mobility within the community. The question posed in this study is whether this mobility can be achieved without the operation of an urban VTOL transport.

It is contended that a sound economic growth of the urban community will require the use of helicopter transports in the 1980's. Further, it is believed that the helicopter will be to intracity transportation in the next 30 years what fixed wing aircraft have been to intercity transportation in the last 30 years.

Air transportation has been the lifeline to national economic growth. It will have the same dramatic impact on the future economic growth of our urban areas. The difference is that the distances involved in the urban community are typically 20 times shorter. As such, the air vehicle involved will be different but the job will be the same.

The urban transportation problem has resulted in great emphasis being placed on the development and modernization of mass transit for improved mobility in the growing urban areas. This effort is properly looked upon as an important solution to moving a large number of people in the shortest period of time. However, there is an inclination of many planners to look upon surface rapid transit as a panacea for resolving the entire needs of the urban communities to the exclusion of alternate transportation modes, such as air transport for special transport requirements. This position is unsound and needs to be changed for several reasons. First, it can be shown that the urban population and employment growth has been occurring at a more rapid rate in the metropolitan rings than in the central cities now serviced by rapid transit systems. Second, this decentralization of urban areas increases the cost of the surface transportation systems because of the exponential growth in area or increased line haul miles and the increased equipment needs to provide the service. Third, the economic requirements of urban decentralization can be correlated with national economic growth that was accompanied by the growth of air transportation and stems from the importance of time saving as travel distances increase. Fourth, the helicopter transport is a practical solution to meeting urban economic development requirements. It is practical in terms of cost, speed, noise, safety, convenience and land requirements, being at a development and operational stage similar to that preceding the large scale introduction of the DC-3. The technology is now ready to be effectively exploited for the benefit of special urban transportation requirements.

These reasons dictate the need for the development of a helicopter urban transport in conjunction with other modes of transportation. Let us examine each of these reasons more carefully.

URBAN GROWTH

As urban population has grown, it has been accompanied by a greater increase of people living outside central cities than in central cities, as shown in Figure 1, with projections to 1985.

In addition, this pattern is also reflected in a significantly greater rise in total employment outside of central cities as compared to the central cities, Figure 2. These patterns reflect a clear decentralization of business and population around metropolitan areas and a resultant increase in distance between many companies doing business with each other in these areas. In this decentralization picture, it is also found¹ that transit usage does not stem the tide of decentralization of population and employment from the central city. In fact, it has been found that central cities with the highest transit usage consistently exhibit the smallest increases or the largest declines in employment and population in both their central cities and metropolitan rings. Yet, in this decentralization movement, massive emphasis is being put on rapid transit servicing central cities to the exclusion of alternate modes of transportation that could provide rapid service between business enterprises in the metropolitan rings.

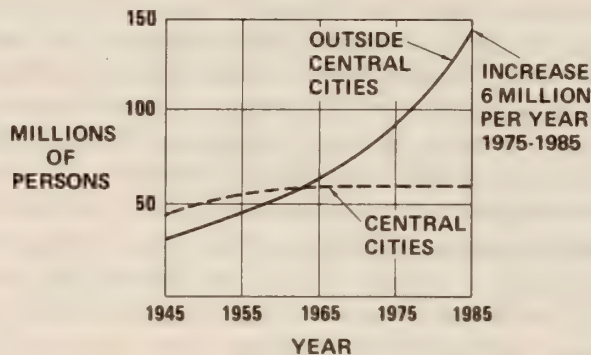


Figure 1. Urban Population Growth*

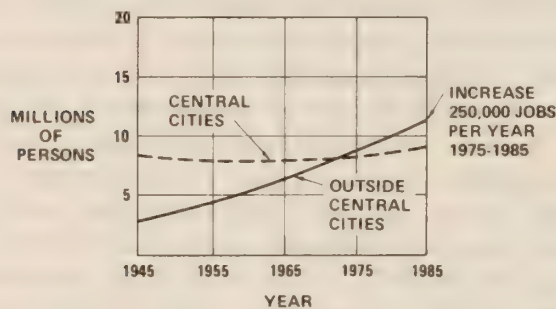


Figure 2. Total Employment for the 24 Largest Cities in Manufacturing, Trade and Selected Services*

*Source: A. Ganz, "Emerging Patterns of Urban Growth and Travel," MIT, Project Transportation

¹ Meyer, J.R., Kain, J.F., Wohl, M., "The Urban Transportation Problem," Harvard University Press, Cambridge, Mass.

SURFACE TRANSPORTATION NEEDS

The geometry of the expanding metropolitan radius results in an exponential growth of the area needing transportation service. It follows that this requires a greater investment in rights-of-way for all surface modes and an increase in mileage, facilities, and equipment to provide the needed service. With this expansion of distance, the need for time-saving transportation modes becomes a greater economic necessity.

TRANSPORTATION AND ECONOMIC GROWTH

The need and development of time saving transportation modes was at the forefront of U.S. economic development. This need was manifested in the exponential growth in U.S. commercial air transportation after World War II as shown in Figure 3. Accompanying this growth was an exponential growth in domestic trade as reflected by the revenue for various modes of domestic property shipments shown in Figure 4. This growth in trade correlates with the growth in air travel because the entrepreneurs developing new business made up approximately two-thirds of the total travel, increasing exponentially (per Figure 5), with increased trade.

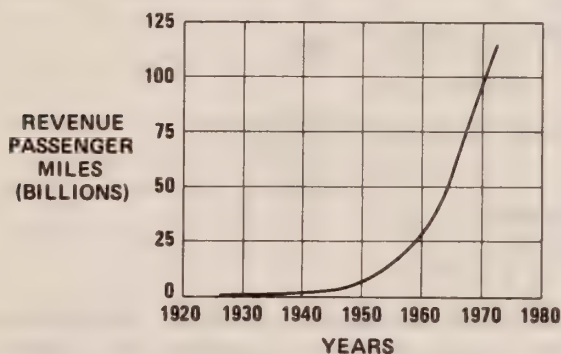


Figure 3. Domestic Air Travel*

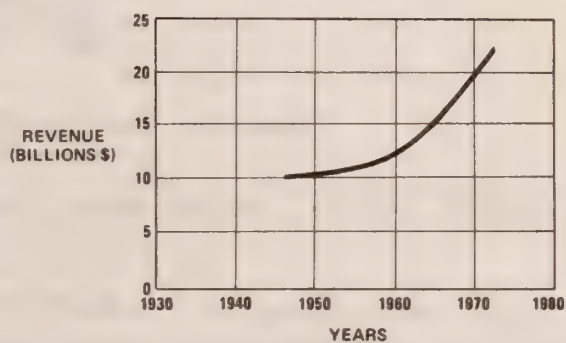


Figure 4. Domestic Shipping Revenue From Motor Carrier, Air and Rail Transportation**

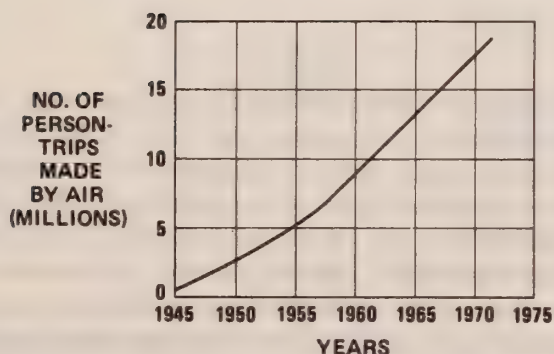


Figure 5. Business Air Travel***

*Source: "Handbook of Airline Statistics" and "Air Carrier Traffic Statistics," Published by CAB.

**Source: "1969 Business Statistics" and "Survey of Current Business," U.S. Department of Commerce.

***Source: "1963 and 1967 Census of Transportation," U.S. Department of Commerce.

To facilitate this growth in air transportation and economic development, the air transport industry developed the transports with continually increasing capability and reduced cost. This made available the capacity, as shown in Figure 6, and the cost saving to stimulate the growth of air transportation. Of course, these factors were also accompanied by increased service to more cities and airports in all kinds of weather, plus greater safety, comfort and convenience, which is the history of U.S. transport aviation development. However, it must be remembered that this evolution started with the imagination and vision of many great aviation pioneers in industry, airlines and government. They recognized the potential of an unproven system to effect the

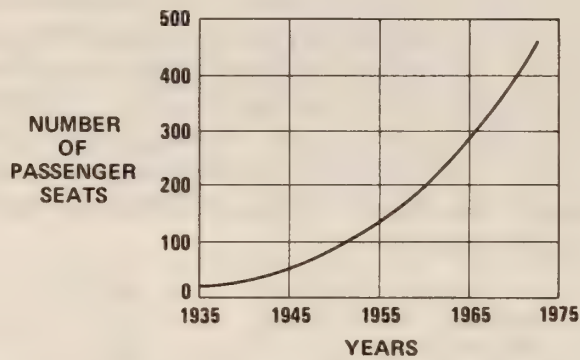


Figure 6. Growth in Fixed Wing Aircraft Size*

*Source: Jane's, "All the World's Aircraft."

kind of time savings at a premium price that eventually became a stimulus for U.S. economic development tying the nation closer together and stimulating the expansion of foreign trade. This same phenomenon applies to the growing urban areas to assure economic development within specific areas and between areas. There is a need for air transportation to assure economic viability and growth.

URBAN HELICOPTER TRANSPORTATION

In the 1980 period, we are faced with the following: increased congestion from a growing number of automobiles; the prospect of paying premium cost for rights-of-way; and more equipment for new rapid transit systems to service the metropolitan rings and, in many urban communities, to service the central city. The decentralization of the city amplifies all of these problems as the radius increases and the area goes up exponentially. In this period of increasing distances between urban industrial enterprises doing business together and between enterprises and commercial airports servicing visiting businessmen, there is a growing need for a new transportation system: one that is not impeded by surface congestion, requires a relatively small investment, uses a minimum of premium land, and offers the potential of speed, low cost, low noise, safety, convenience and comfort to an important segment of the traveling public.

The way to achieve this objective is by introducing a helicopter that is smaller than used to date because of the ability to master the problems and make it economical at this time. The concept proposed is a light twin engine helicopter with a 10-passenger capacity, equipped for IFR, incorporating quieting features capable of reducing noise by 90 percent from that of more conventional designs and providing a structural integrity and safety exceeding any commercial design ever built. This helicopter would provide: average speeds from origin to destination that are three or more times faster than that of surface modes, an operating cost equal to that of a taxicab, great flexibility in route structure, a utility value² that now is twice as great as that of a taxicab and could exceed that of a private automobile as the helicopter system was developed to provide lower helicopter maintenance and more helistops.

In support of this solution for intracity transportation, a few facts will be examined. If the helicopter today is compared to the fixed wing aircraft in size, Figure 7, the helicopter is at a point today that fixed wing air transportation was at about the time the DC-3 was making its impact on air transportation growth, approximately 30 years after both their inception.

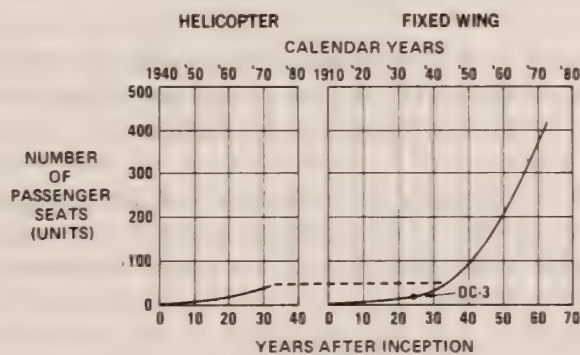


Figure 7. Transport Aircraft Size Comparison*

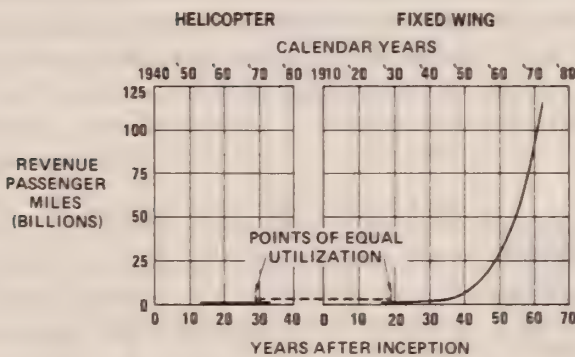


Figure 8. Transport Aircraft Utilization**

*Source: Jane's, "All the World's Aircraft."

**Source: "Handbook of Airline Statistics," CAB.

² Utility Value =
$$\frac{\text{Passenger Volume} \times \text{Average Speed}}{\text{Total Cost}}$$

However, a comparison of helicopter and fixed wing utilization, Figure 8, indicates that the helicopter has fallen behind by approximately ten years. This is due to the lack of community acceptance resulting from helicopter noise, reliability deficiencies, high cost and proximity of operations to residential and business establishments. In more recent times this problem has worsened as evidenced by the decline in helicopter airline operations shown in Figure 9.

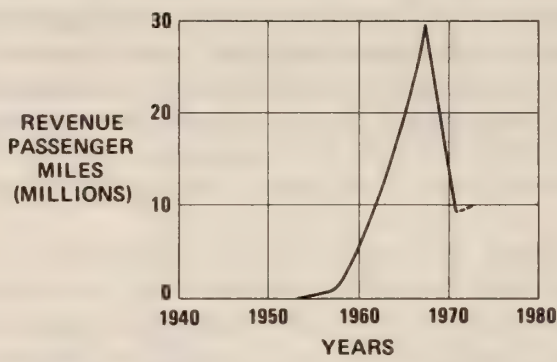


Figure 9. Helicopter Transport Utilization*

*Source: "Handbook of Airline Statistics," CAB.

Therefore, what is needed is a helicopter of the type previously described for intracity operation that satisfies the low noise and high reliability criteria that would encourage user and community acceptance.

Looking to the future, it is clearly feasible for industry to provide a 10-passenger helicopter operating in a commuter mode between, say, two high traffic density points with a high enough load factor on a 10-minute departure schedule to experience a low cost operation. As in the early days of fixed wing transports, some small subsidy might be required at the outset but it is expected to operate without subsidy and at a profit as the system, equipment, and facilities evolve. Figure 10 depicts the projected cost through the year 2000. Compared to other modes of transportation, the cost can be expected to be competitive in the next 30 years, but the average speed of the helicopter will far exceed that of the surface transport — adding greatly to its utility value for business and economic needs in the megalopolitan area.

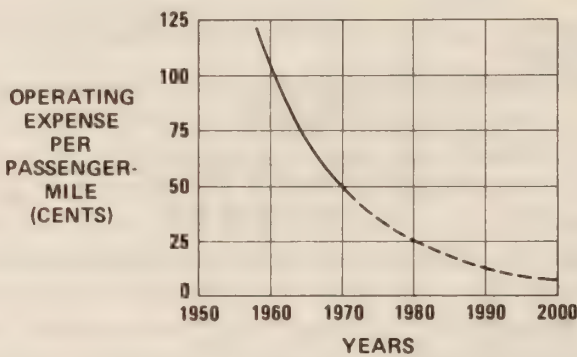


Figure 10. Helicopter Operating Expense**

**Source: "Handbook of Airline Statistics," CAB.

The thesis is that the growth of the helicopter is consonant with the growth of the city. Helicopter utilization is dependent on having a machine that is acceptable by the community to fly over their houses and into conveniently located heliports. The economic and business need already exists when one considers that approximately three million trips under 50 miles are made by air, and half of these are made for business annually.³

In addition, the helicopter transportation system will require approximately one-tenth the land needed for STOL aircraft systems and 1/300th the land needed for rail and road transportation serving a 30-mile equivalent route.

Therefore, we find that a helicopter transportation system can be an effective alternative transportation system to alleviate the traffic congestion in urban areas while offering all of the other benefits cited, most important of which is the stimulus for sound economic development.

In view of these facts, we believe it is time for action to assure balanced transportation development. The Transportation Department has assessed⁴ that \$670 billion will be required for transportation through 1990. Of this, \$560 billion will be required for highway construction and \$63 billion for public transit needs. Of the latter, 70 percent would be for railways. It is proposed that approximately 1 percent of the public transit funds or approximately \$500 million be used to develop a helicopter transportation system for 25 major cities over the next 20 years. The money would be disbursed as follows: \$100 million for a helicopter development program that could be paid back from royalties on helicopter sales; \$250 million for ten terminals to begin with in each of 25 major metropolitan areas; \$50 million for air traffic control facilities; and \$100 million for personnel training, administration, and general expenses.

This investment will support the next major economic growth in the United States that will take place in the urban areas outside of the central cities, and contribute to the development of better than 250,000 jobs per year in the manufacturing, trade, and selected services outside the 25 central cities. These jobs represent an increase in local income in excess of \$100 billion over a 20-year period from 1980 to 2000. This income will have a multiplying effect on national income as well.

Thus, an investment of \$500 million helps to create and support an increase of \$100 billion in the 20-year economic base of the urban areas outside central cities at a time when there is a growing resistance to extending freeway and railroad rights-of-way that threatens to restrain economic growth.

³ "1967 Census of Transportation, National Travel Survey," U.S. Department of Commerce.

⁴ "1972 National Transportation Report," Department of Transportation, July 1972.

The facts presented here warrant an immediate effort to invest money in the development of the basic helicopter and an experimental operation in a selected location. This will permit the early evaluation of the system to establish the costs and operating requirements for national implementation.

The necessity for a helicopter transportation system for urban application is the key to the growth of employment and economic viability of the developing urban communities. A helicopter transportation system must be regarded as a necessary supplement to rail and road development.

The Helicopter is Coming to Town

Thomas R. Stuelpnagel
Vice President and General Manager
Hughes Helicopters

THE HELICOPTER IS COMING TO TOWN

With 80 percent of the U. S. population moving into the urban centers by 1990, more helicopters will be coming to town to serve these people.

The helicopter may well be the most effective vehicle yet devised for improving the quality of life in the city. It can do it by accelerating the location of new plants away from the city center and closer to the work force, thus decreasing the commuter traffic congestion in the central city.

Use of the helicopter in the city is very much an evolutionary development. The helicopter itself must become more "citified" so the public can more readily accept it and support the development of the needed public heliports.

The helicopter's past role in the city has been to provide emergency rescue and some transport functions at a low level of activity. This has grown to include the present use of helicopters in police patrol, fire fighting, banking, and airline operations. These functions will be accompanied in the future by increased use of helicopters for traffic control, freight delivery within and between cities, construction, urban bussing, and emergency rescue from high-rise building fires and freeway accidents.

While some of the future applications are in evidence today, the high time urban uses are principally in the public safety fields of law enforcement and fire fighting. The public itself plays a rather passive role in the use of helicopters in the city. Future urban helicopter use will grow as public confidence is built on the achievements of helicopters in public service and its demonstration as a good neighbor in terms of safety and quietness. In addition, urban use will grow as industry recognizes the economic leverage that the helicopter can provide. Together these forces will evolve a public and private heliport system that will expand helicopter usage greatly. In the future, one will look into the sky of a large city and see a dozen helicopters flying at all times.

TREND IN URBAN OPERATIONS

Studies of the past growth of the urban helicopter fleet in the U. S. provide a means of projecting the future fleet size as shown in Figure 1.

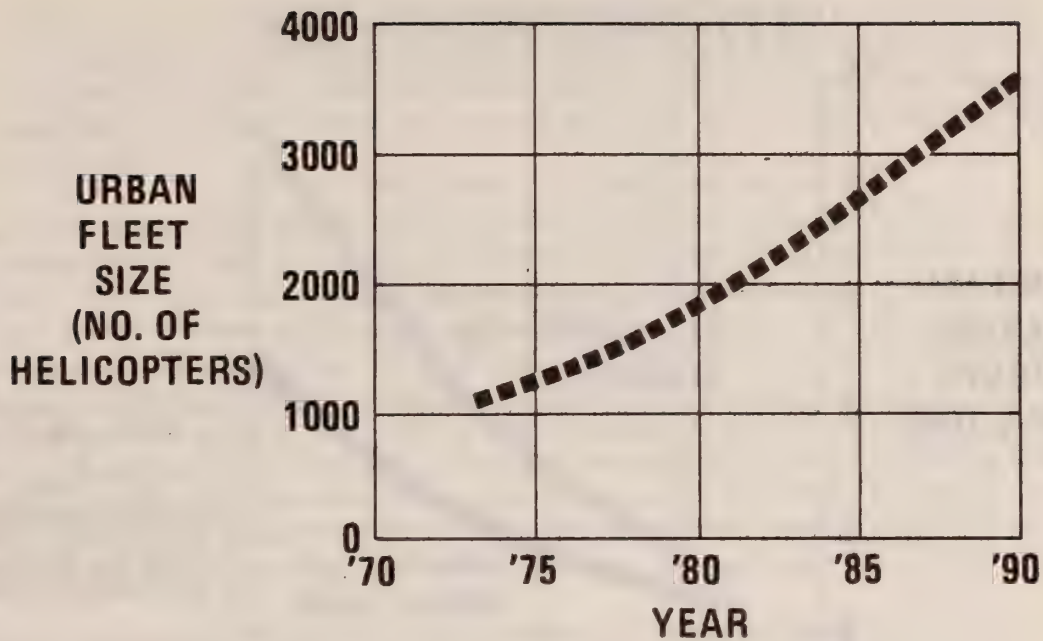


Figure 1. Helicopter Urban Fleet Size

At present there are approximately 1200 helicopters operating regularly in urban areas of the U. S., mostly single engine. This number is expected to compound to 3500 helicopters in the city by 1990 which will represent 45 percent of the total active U. S. helicopter fleet of 7800 helicopters projected in 1990.

As the urban fleet grows threefold between 1973 and 1990, so will total flying hours as shown in Figure 2. Urban flight-hours will increase tenfold between 1973 and 1990, and represent one-half of all U. S. helicopter operations. This flight-hour growth will be driven by a large number of high time applications such as law enforcement, urban bussing and freight delivery. These helicopters will operate up to 4000 flying-hours per ship annually by 1985 as shown in Figure 3.

APPLICATIONS

To understand how the level of operations shown in preceding paragraphs will be achieved, one needs to understand the primary role of the helicopter in the city in the coming years, namely public service. Success in this area is leading to public acceptance and demand for expanding urban helicopter service. These services will require more public heliports -- the key to increased helicopter usage.

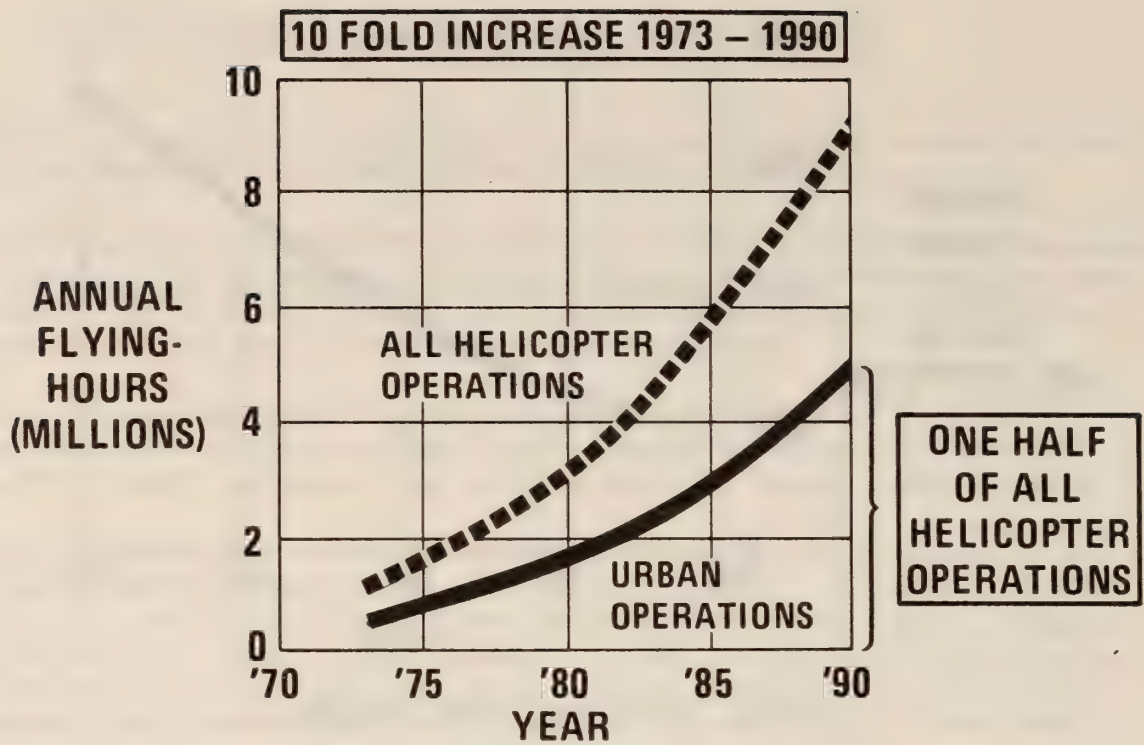


Figure 2. U. S. Helicopter Operations

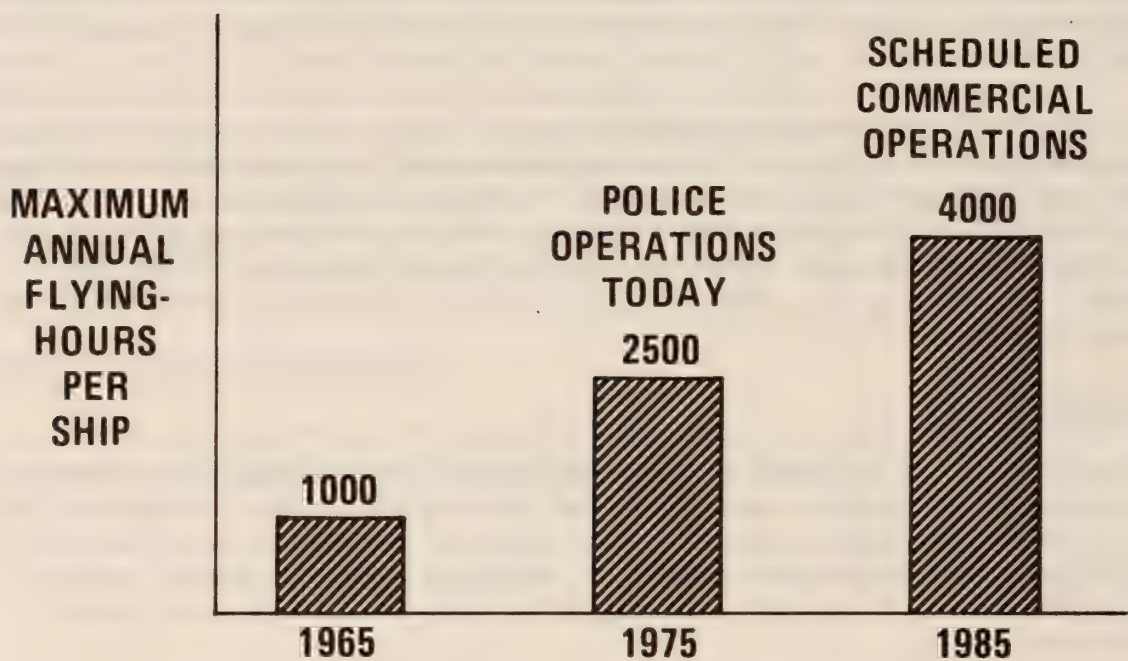


Figure 3. Helicopter High-Time Flying-Hours

Law Enforcement. One of the best established public services is helicopter patrol. It literally and physically adds the "third dimension" to law enforcement. The airborne position of the helicopter provides an operating capability which amplifies the effectiveness of ground vehicles and provides some unique features as well.

The patrol helicopter flying typically 3 times faster than the patrol car, has demonstrated its ability to survey 30 times more area in a given period of time, and respond to calls 5 to 10 times faster. Fast response is an essential factor in the 10 percent average crime reduction achieved and the 2 times higher criminal apprehension rate. From its "see and be seen" position, the helicopter discourages many potential law violators and gives protection for the ground patrolman on a call. Its quick response to a call also adds protection for the intended victim. In addition, operation in the third dimension permits the helicopter observer to locate stolen cars and other property, and prevent vandalism of public property. In this area alone, the cost saving to the public is typically 10 times greater than the total cost of helicopter operation.

The patrol helicopter offers other advantages. It assures less risk of riots starting due to more effective crowd control. It precludes the necessity for high speed ground chases, which often result in police and citizen death. Since no automobile can outrun a helicopter, there is even less incentive for the suspect to drive fast and attract attention.

Looking to the future, one goal of law enforcement agencies is to achieve less than 2-minute response time on police calls in order to increase apprehension and discourage crime. Figure 4 illustrates a future system being evaluated to supplement present techniques. An omnidirectional radio transmitter on top of a building is automatically activated by an alarm system. The transmitter sends out a coded signal indicating the type of establishment and location to an airborne patrol helicopter. The coded signal provides the airborne observer with the information he needs to direct the pilot to the call site and select the tactical operation to be employed. At night the helicopter can employ its searchlight to spot suspicious persons or use it like a broom to "sweep" an area forcing suspects into a direction where ground units are waiting. Infrared detection is also being used where the visible searchlight is inappropriate.

The cost saving and effectiveness being demonstrated establishes the law enforcement patrol helicopter as an essential tool. Cities using helicopters for law enforcement may invest 1 to 3 percent of their total law enforcement budget in exchange for a severalfold return in crime reduction and other advantages. Citizens have shown 90 to 95 percent support for the use of helicopter patrol. It's only a matter of time for this attitude to spread more widely throughout major urban areas of U. S., raising passive acceptance to public demand. This is expected to lead to a sixfold growth in law enforcement helicopters between now and 1990, consisting of the operation of approximately 1500 law enforcement helicopters, as shown in Figure 5.

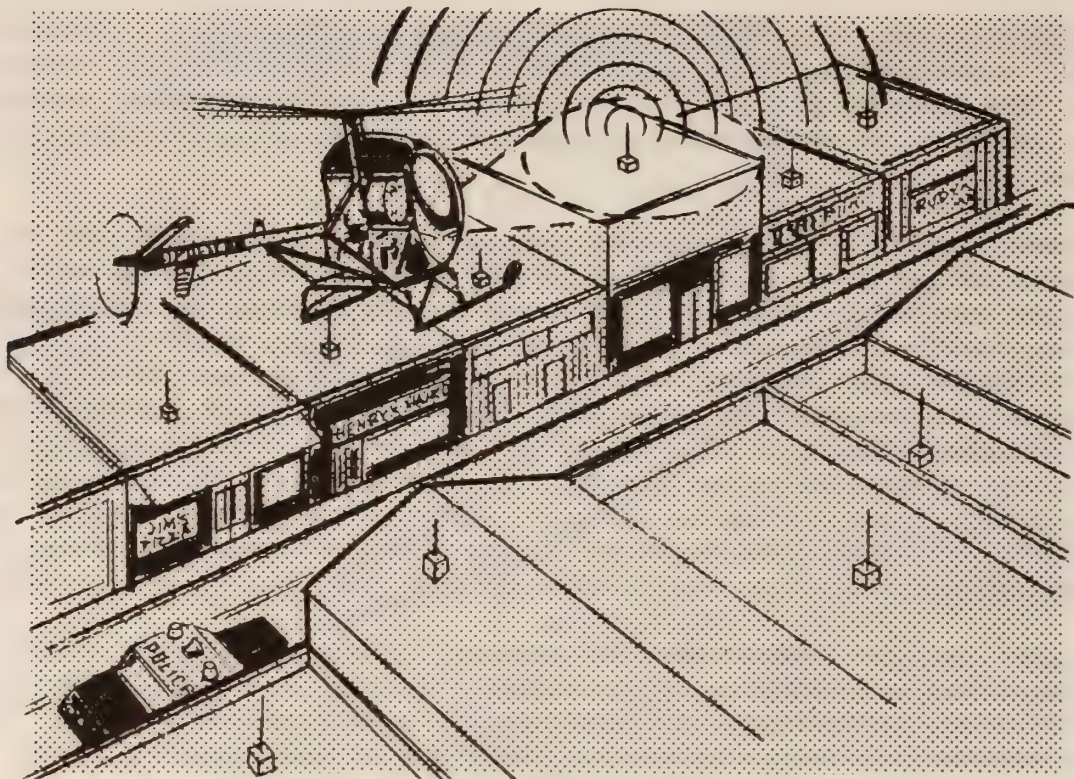


Figure 4. Coded Radio Alarm System for Patrol Helicopter Operation

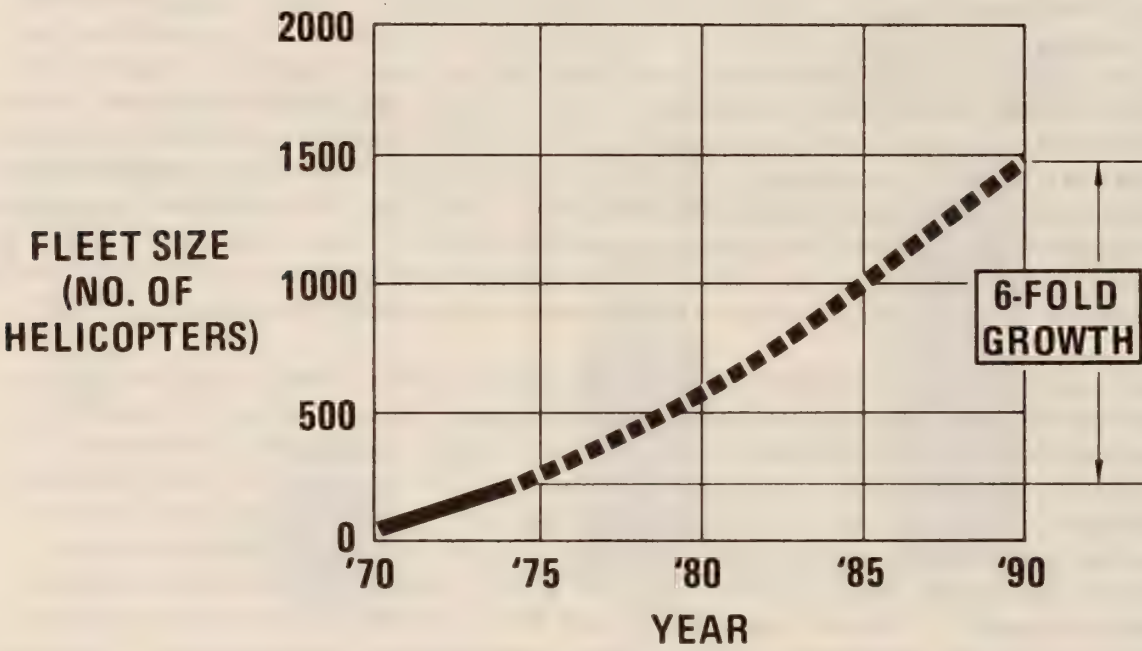


Figure 5. Growth in Law Enforcement Helicopter Application

Traffic Control. A second public service of the helicopter is in ground traffic surveillance and reporting. While it is commonplace today, new possibilities exist for further exploitation of this role. For example, this function can be turned from passive to active control by a police helicopter whose function it is to monitor a 20-mile stretch of freeway or expressway, noting traffic build-up and congestion zones per Figure 6. Based on predetermined relationships between the traffic flow on the freeway and the traffic volume entering the freeway, the airborne controller can set traffic signal timing on the entry ramps by radio relay to regulate the inflow.

Studies show that traffic signal control on major arteries can increase traffic volume from 1675 vehicles per lane-hour to 1930, an increase of 15 percent. At the same time, traffic speed is increased 50 percent. In a city like Los Angeles, 12 helicopters could patrol all the major freeways during the 4 rush hours, with each helicopter making a pass through its 20-mile assigned stretch each 10 minutes or less, providing timely updating of traffic light sequencing. In the event of severe accidents, the helicopter could be used to remove victims to emergency trauma centers and even move auto wrecks out of the way to restore traffic flow.

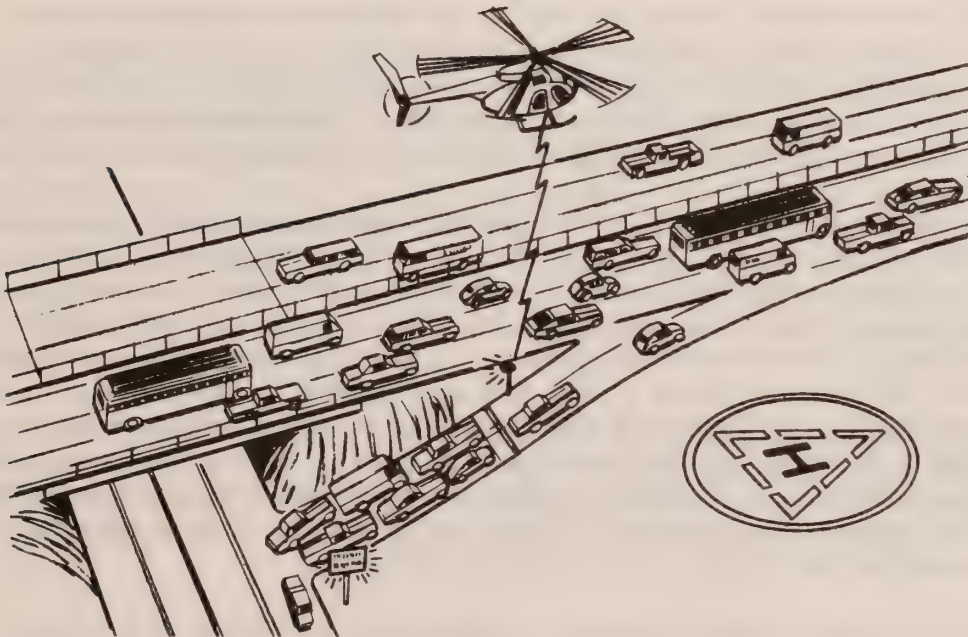


Figure 6. Helicopter Radio Control of Traffic

To achieve the same capacity as derived from helicopter traffic control would cost over \$200 million in construction of additional freeway lanes. On an annual basis, there would be an eightfold saving in cost by using helicopters. This would be a cost saving of \$16 million per year comparing the cost of ownership and operation of the freeway, and the total operating cost of the 12 traffic control helicopters with personnel. Since the helicopter performs its traffic functions 4 hours per day, approximately 200 working days per year, the community can derive additional benefits such as rescue and patrol in the remaining hours and days at no additional cost.

A side benefit of improved traffic flow is the time saved by the commuting public. In a city such as Los Angeles, this can be valued at \$100 million per year in the saving of commuter travel time based on \$3 per hour per person. Of course, the saving in frustration with a constant traffic flow would win the most support of all for the helicopter.

High-Rise Fire Rescue. Another public service function where the helicopter has already proven itself dramatically effective is in high-rise building fire rescue. In the City of São Paulo, Brazil, in February 1972, in one of the most spectacular fires ever to occur in a high-rise building, helicopters rescued 380 people from the rooftop of the Andraus Building. Over 125 landings were made in a 5-hour period.

In a city like Los Angeles, there are some 140 high-rise building fires per year. Up to 300,000 people use these buildings daily. With this exposure there is a sizeable potential for the loss of life. Furthermore, the exposure is growing with the increasing number and height of high-rise buildings. Helicopters present an economical backup system for life saving in case of fire.

One such approach is shown in Figure 7, which might appropriately be called a High-Rise Building "Buddy" System. The concept consists of assigning a number of fire department and commercially operated helicopters to be on call for fire rescue work on a priority basis. The system plan would pair high-rise buildings for transporting people to a safe refuge if people became entrapped and were forced to the roof. The roof of each building would have personnel rescue nets stored which would be used to lift passengers off the roof by the helicopter without the ship having to land. The helicopters would transport the people to the "buddy" building for safe refuge where they would proceed to the ground via elevators. Heliports on the top of such buildings would be an appropriate safety feature but not essential.

Helicopter fuel could be stored in tanks on the top of some nearby parking garage or underground in an open area such as a nearby park. By this technique, it is possible for a single light turbine helicopter to rescue as many as 10 persons at a time and 200 persons per hour. More than one helicopter could be used in tandem as required.

EMERGENCY RESCUE OF 200 PERSONS PER HOUR BY ONE HELICOPTER



Figure 7. High-Rise Building "Buddy" System for Emergency Rescue

Urban Forest Fire Fighting. The same helicopters used for high-rise building fires can also provide a capability to fight fires in forested areas of major cities such as Los Angeles. This can be implemented with a number of heliports located throughout the forested areas that are equipped with buckets, retardants, water, mixers and helicopter fuel. Each heliport could service a 12 square mile area with no point being more than 2 miles from the heliport. A two-helicopter (light turbine) brigade could provide very rapid response, bringing in a tactical fire team on the first run. Two such helicopters can perform precision delivery of 2500 gallons per hour of retardant on the fire, as illustrated in Figure 8.

Quick and precise placement of this retardant can prevent vegetation fires from getting out of control as in the 1961 Bel Air fire in Los Angeles' Santa Monica Mountains. The City of Los Angeles experiences 5000 vegetation fires in a single year and helicopters are now an effective means for fighting such fires.

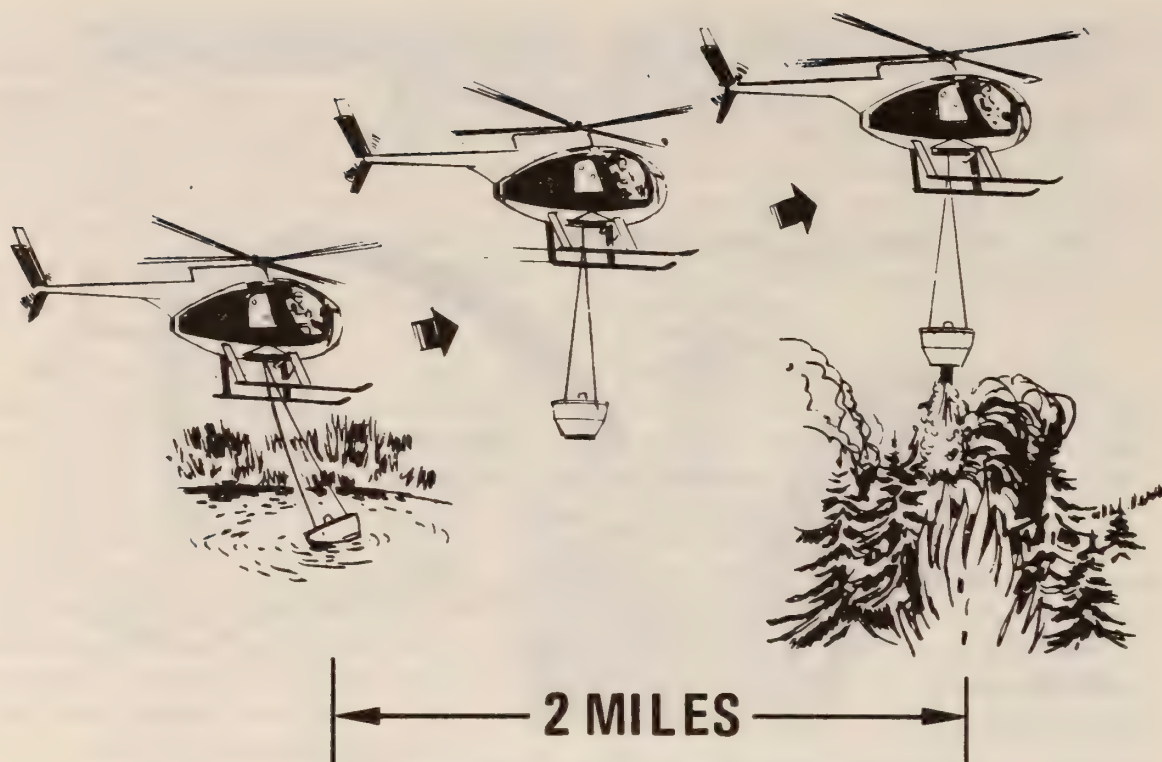


Figure 8. Helicopter Fire Fighting Bucket Brigade

Highway Accident Rescue. The helicopter's capability for emergency rescue was recognized during the Korean War and employed in civil agencies on a limited basis in the late 1950's and early 1960's. The application came into its own in the late 1960's and early 1970's during the Vietnam War. The true civil advantages have been recognized in such programs as MAST but have yet to be exploited on a large scale throughout the U. S. because of the cost of operation compared to ground ambulances. As the cost of operation of ambulance helicopters is reduced into the 1980's, this application will experience dramatic growth.

One technique that can be employed for highway accident rescue is to put the helicopter on call from other duties such as airborne patrol. Upon receiving a call, the helicopter proceeds at a speed of 150 to 175 mph to the accident scene. Descending along the highway the helicopter can use its own siren and flashing lights, as necessary, to stop the traffic, landing on the highway as shown in Figure 9. Given a network of hospital trauma centers, the helicopter can be at the hospital heliport in 10 to 15 minutes, having spent less than 5 minutes on the ground to pick up the patients. Actual tests have shown consistently that the helicopter ambulance can arrive at the accident scene in less than one-half the time of a ground ambulance. The first hour after a trauma occurs is considered the "golden hour" for the victim when life hangs in the balance. Thus, ambulance speed to the accident scene and then to the trauma center is vital to saving lives.



Figure 9. Helicopter Ambulance for Highway Accident Rescue

Actual helicopter ambulance operations conducted in Arizona, Pennsylvania, and Maryland show a 50 to 80 percent life saving capability from the delivery of accident victims to trauma centers or regular hospitals by helicopter. In the U.S., there are approximately 50,000 motor vehicle accident fatalities per year. This means that over 25,000 lives per year potentially could be saved with this life saving technique. This represents over \$3 billion in unnecessary economic loss to American families every year.

In summary, the applications show that the helicopter makes a sizeable impact on public safety as well as the public purse. Yet its real value is only beginning to be recognized by local, state, and Federal governments. Why? Because there is a lack of demand from both the public and private sector due to helicopter cost and a lack of wide spread confidence in the helicopter's safety and acceptability to operate over the city. The helicopter industry must accept the challenge and provide the improvements required to win public confidence.

HELIPORTS: KEY TO FUTURE GROWTH

As the helicopter industry does the job to certify the helicopter, the growth in applications and public demand for them will generate the need for public use heliports. The heliport is the key to future growth of helicopter applications in the city. Studies of urban transportation needs in the 1980's indicate a need for at least 250 public use heliports distributed between 25 major cities of the U.S. The present status of public use heliports indicates that less than 10 percent of these are available today. Figure 10 shows the total lack of public use heliports in most of our major cities at a time when there is a vital need for alternative transportation modes. With the availability of public use heliports, entrepreneurs are in a position to bring the helicopter to town on a larger commercial scale.

	<u>NUMBER OF HELIPORTS*</u>
• LOS ANGELES.....	0
• NEW YORK.....	6
• CHICAGO	0
• WASHINGTON, D.C.	0

LESS THAN 10% AVAILABLE NOW

*NON-AIRPORT

Figure 10. Public Use Heliport Status

FUTURE URBAN HELICOPTER REQUIREMENTS

To operate in the city, helicopters must have: a low noise signature; exceptional flight safety; increased utility; and a low operating cost competitive with alternate ground transportation.

Quieting. Since the people were in town before the helicopter, the helicopter has to meet the people's requirements for quietness. It has to be a good neighbor. Excellent progress has already been made in quieting as shown in Figure 11. Overall sound pressure level reduction of 95 percent has been demonstrated between 1961 and 1974 in light piston and turbine helicopters. This achievement has been realized by such improvements as reduced rotor tip speeds, rotor tip modification, increased number of blades and engine muffling. The result has been to make the light helicopter barely perceptible in the daytime over the city at 500-foot altitude. This has been very important to the successful acceptance of law enforcement patrol helicopters in the city. Further improvement is required to achieve quieting for nighttime and residential operations with low ambient conditions. Therefore, the objective is to reduce overall sound pressure level another 80 percent by 1990. This quieter helicopter will fly unnoticed day and night, and can be welcomed in the city in whatever numbers needed.

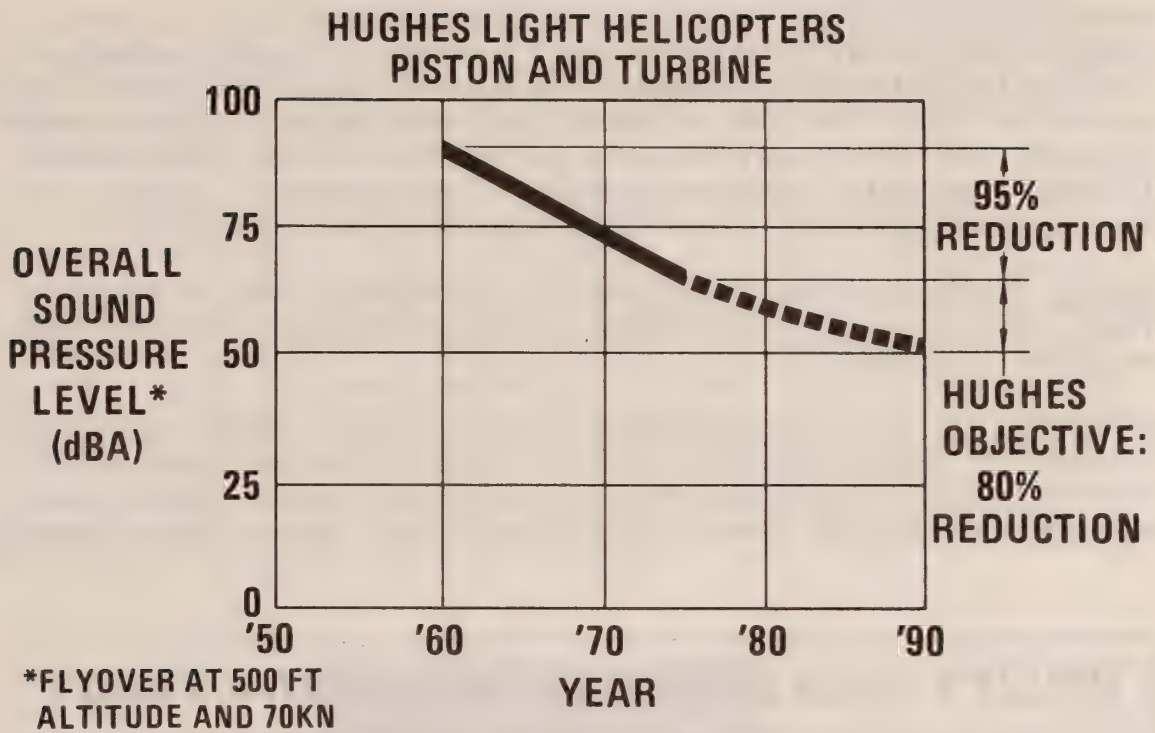


Figure 11. Helicopter Quieting

Safety. To complete its acceptable "city" image, the helicopter will have to demonstrate exceptional flight safety, better than other city transportation systems. Helicopter safety has already made great strides in the last 7 years as shown in Figure 12. In the example shown, safety has been improved two-fold since 1967. Furthermore, this record demonstrates that helicopters can achieve a safety which is substantially better than all general aviation aircraft.

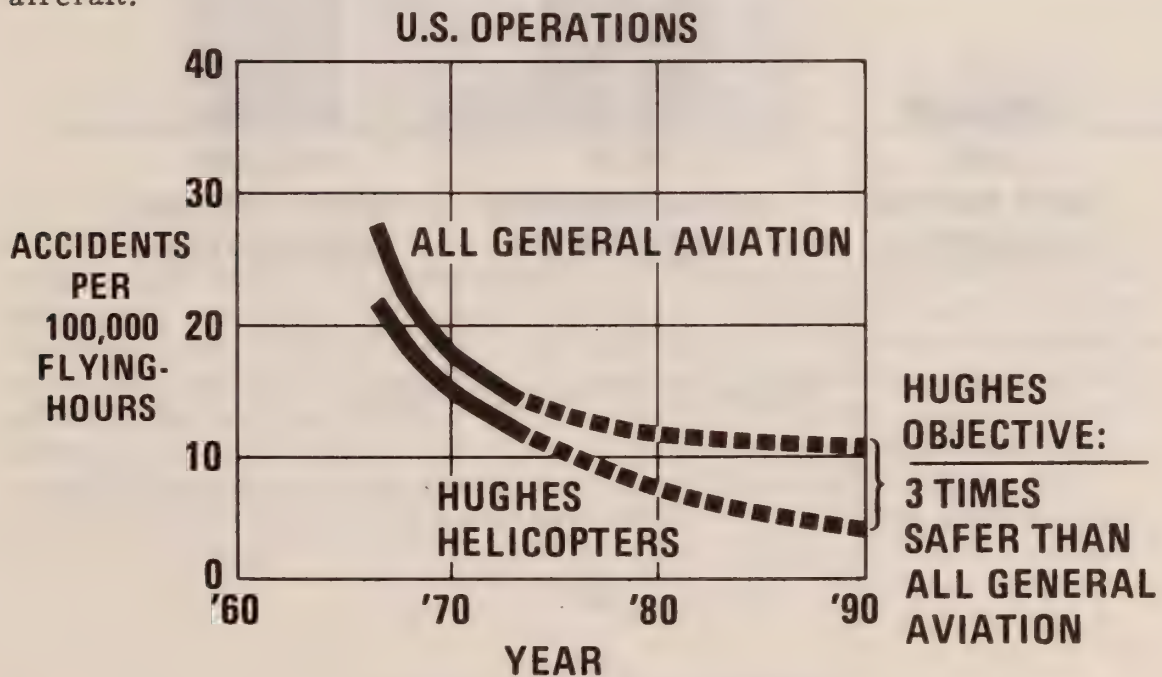


Figure 12. Helicopter Safety

However, this record must be improved further for all helicopters if the growth of this industry is to be realized, particularly in urban operations. The objective is to make the helicopter three times safer than general aviation aircraft by 1990. This is an achievable goal since military helicopter training operations have already attained a sustained level of four accidents per 100,000 flying-hours. Fixed-wing general aviation safety is projected to be near its maturity having 30 years more experience than helicopters.

Utility. Helicopter utility, measured as a function of payload, number of seats, speed and range, will experience twice the growth by the mid-1980's as shown in Figure 13.

This will be derived from the normal growth in power-to-weight ratio and reduction in specific fuel consumption (sfc) that has been demonstrated in aircraft engines. The increased engine performance can be used for extra margins in payload and speed which are particularly useful in urban operations.

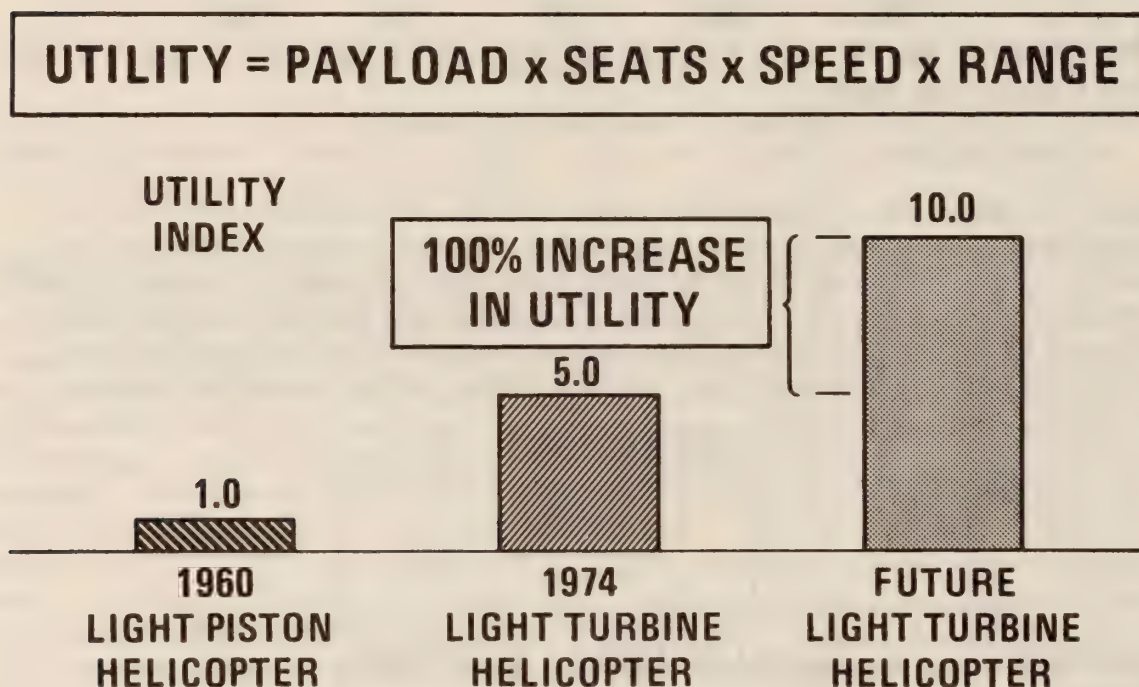


Figure 13. Helicopter Utility

One Approach. The Hughes 500D is an example of how these requirements can be implemented. As a light turbine helicopter it reflects the classic size and performance needed for urban application into the 1980's. Specific attention has been given to low operating cost to make the helicopter competitive with alternate modes of transportation.

The Hughes 500D, shown in Figure 14, comes to town, in essence, as the "Volkshubschrauber", the people's helicopter, to serve the public. It is a 5-7-place light turbine helicopter with a 5-blade main rotor 26 feet in diameter; small enough to land in the street and powerful enough to carry increased payloads in quiet operation. It features a T-tail for increased stability and improved handling. The increased utility is obtained from the more powerful 420 horsepower Allison 250-C20B turbine engine that is flat rated for hot day operation. The power is used by upgrading the ship to fly at a speed of 175 mph and carry full loads in a hover-out-of-ground-effect at 5000 feet on a hot day (ISA + 20°C). The 500D can carry nearly three-quarters of a ton inside and one ton outside as shown in Table I.



Figure 14. Hughes 500D

The 500D provides a 50 percent increase in internal payload and a 15 percent increase in maximum speed while reflecting a 15 percent reduction in operating cost over its predecessor. The operating cost reduction is achieved by increased component reliability and increased time before overhaul on the engine as well as the airframe. The "people's helicopter" is ready to come to town on a larger commercial basis since it demonstrates the qualities needed for increased urban operations, namely: low noise, flight safety, increased utility for the same size helicopter, and a reduced operating cost.

Table I. Hughes 500D Payload Options

	FULL FUEL	(LB)	
		30 MIN. FUEL	
		INTERNAL LOAD	EXTERNAL LOAD
GROSS WEIGHT	3000	3000	3550
EMPTY WEIGHT	1320	1320	1220*
PILOT	170	170	170
FUEL AND OIL	420	100	100
PAYLOAD	1090	1410	2060

~ 3/4 TON INSIDE

~ ONE TON OUTSIDE

*INDUSTRIAL CONFIGURATION

URBAN APPLICATIONS GROWTH

Competitive operating cost has been cited as a key to extensive commercial operations in the city. The helicopter is moving toward the time when its operating costs will be equal with alternative modes of transportation for a particular job. As the helicopter's hourly operating costs are reduced, its use will increase further for high-time jobs such as a business transport or a freight transport for operations within the city and between cities.

Business Transport. With the development of public use heliports and the reduction in operating costs, the light helicopter will come into its own as a machine to improve the quality of life in the city. Teamed with the computer, the helicopter will encourage managements to decentralize operations to separate plant sites in the urban fringe, closer to where employees live. For example, the helicopter will permit the daily transport of 20 executives to a fringe area plant site from the main plant in lieu of 2000 plant workers who might have had to drive to the main plant. This can represent up to 100:1 saving in energy consumption and 2000 fewer person-trips through an increasingly congested central business district. Instead of moving more and more people on freeways and rapid transit systems, the helicopter provides a simple way to decrease the need.

This approach could prove to be the most exciting and lowest cost solution to the urban transportation problem. As such it is worthy of consideration in the Department of Transportation long range plan. DOT has heretofore shown

little interest in the helicopter since it has considered its use principally from the standpoint of mass transportation.

Between 1975 and 1985, the seat mile cost of a light turbine helicopter is planned to go from 12¢ a passenger seat-mile to 4¢* (in 1975 dollars). As a basis of comparison, the taxicab, frequently used for executive transport, will cost 3¢ per passenger per mile (in 1975 dollars) between now and the mid-1980's, with no reduction expected in operating cost. This translates into a 20 mile trip direct cost of \$3.20 for the helicopter versus \$2.40 for the taxicab. The indirect costs of driver salaries, overhead and profit are additive and could be equal for both vehicles. However, the helicopter, operating above ground traffic congestion, can deliver the passengers up to 2 times faster** than the cab, a time saving of up to 45 minutes versus an 80¢ greater cost. This cost increment is insignificant since the value of an executive's time saved is many times greater. Thus, the helicopter will offer an attractive alternative to ground transportation where the point-to-point operation is compatible with the passenger requirements. But most importantly, it will encourage the executive to make the trip.

Freight Transport. Consistent with earlier studies, the light turbine helicopter will be competitive with the half-ton truck in the 1980's. The importance of this relates to the trucking industry's concern with the increasing costs and impaired service for pickup and delivery of one small shipment at a time in the city. For example, it is becoming increasingly difficult for parcel service companies to provide economic service to small businesses in the city because of the increased travel time and cost. This is eliminating available carriers and causing shippers to seek alternative ways to reduce shipping costs.

The helicopter's proven ability to perform pole and roof-top pickup in banking operations can be a valuable capability for picking up small shipments for other businesses, reducing shipping costs for carriers and providing fast delivery. In banking operations, helicopters pick up bags from branch banks for delivery to computer processing centers and clearing houses. This results in cost savings of \$1 million per year in a large city bank because of the reduced time of cash in transit.

The helicopter can also minimize expensive inventory requirements for high value items. An example of inventory reduction might be the service of computer centers from a central point to a radius of 100 miles (45-minute response time). The service company can provide expensive components, expert technicians or programmers on short notice from the central location, alleviating computer center operators from continuously carrying the repair parts inventory and other overhead costs.

*Based on total operating cost; four passengers; block speed of 175 mph.

**Allowing 30 minutes terminal time for the helicopter.

Functioning as a half-ton truck, the 1980's light turbine helicopter can be expected to operate at a cost of 10¢ to 14¢* per mile of truck travel as compared to 12¢ per mile for a half-ton truck. This allows for the capability of a helicopter to travel in a straight line, saving 25 to 50 percent in ground distance while reaching its destination 3 to 12 times faster than the truck. This can be a boon to the small shipment dilemma as business and industry move to the urban fringe and ground traffic congestion becomes a greater determinant in motor carrier operating costs.

CONCLUSIONS

The helicopter and the heliport will make an important contribution to the quality of life in the city by saving lives, property, money, reducing traffic congestion, and reducing commuter travel by encouraging multiple plant locations. In addition, it will produce industry growth and enhance commercial operations which will create jobs and economic growth of the community. Perhaps with the computer "data link" and the helicopter "people link," no plant need be larger than 5000 people to provide lowest product cost, promote energy conservation and reduce pollution.

As public acceptance and demand for helicopter service ensues, heliports will be developed in the city to permit the wider use of helicopters in commercial operations. The helicopter can service the public and specifically, business and industry needs, for fast, economical transportation. This is the inducement for commerce to grow, creating the jobs and economic development of the community. It has been said before that "the helicopter will be to transportation within the city what fixed wing aircraft has been to transportation between the cities." Specifically, the DC-3 helped to increase domestic commerce and national business growth at an exponential rate. The helicopter can create the same result in the city. Thus, the city is the benefactor when heliports are available.

CHALLENGES

In view of the benefits to be derived by the public, government and industry with the helicopter coming to town, the helicopter industry is challenged to make it materialize. These challenges are:

- make the helicopter three times safer than general aviation
- make it so quiet that it can't be heard at 500-foot altitude

*Based on total operating cost (in 1975 dollars) and a block speed of 175 mph.

- provide block speeds at least two times faster than ground transportation
- make it cost competitive with ground transportation

As the helicopter industry meets these challenges, heliports will appear by public initiative and the helicopter will come to town on a large scale.

The coming era of the quiet helicopter

THOMAS R. STUELPNAGEL

Vice-President and General Manager,
Hughes Helicopters

The coming era of the quiet helicopter

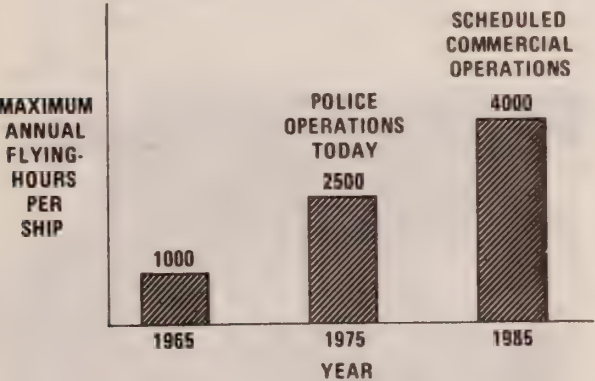
THOMAS R. STUELPNAGEL
Vice-President and General Manager,
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THE subject of the quiet helicopter is receiving increasing attention throughout the world because it is now established that a helicopter can be made quiet. Quietening is also needed as more helicopters are being used over cities and residential areas. To date, little attention has been paid to helicopter quietening because the emphasis has been on achieving maximum payload and other performance. Now that the basic helicopter design has been established, refinements for quietening are becoming practical. The comparison is much like the evolution of the automobile and the truck in the city. Initially these vehicles were noisy. As their number increased and their design evolved, mufflers and sound-deadening materials were skilfully applied to reduce their noise to more acceptable levels for each type vehicle.

Throughout this paper the light turbine helicopter will be used as an example of quiet helicopter development. The OH-6/500 turbine helicopter will be discussed specifically because the most advanced work on quietening has been done with this machine. The results obtained are applicable to other helicopters. We expect all newly designed commercial and military helicopters to incorporate the basic principles of quietening as important design parameters.

NEED FOR QUIETENING

The need for quietening exists especially in the urban environment where helicopters are flying at increasing flight densities over the city centre and out to the residential areas both day and night. Police operations today run as high as 2500 flying hours per machine annually, and commercial operations are expected to reach 4000 flying hours per machine by 1985. Annual flying hours in the



city are projected to grow sixfold between 1975 and 1990⁽¹⁾. In addition, the helicopter needs many landing areas throughout the city to be effective. For these helicopters and heliports to be acceptable to the nearby residents the helicopter must be quiet in landing and take-off as well as in flight and, of course, it must be extremely safe.

The interesting aspect of the helicopter in the urban application is that it is potentially more of a servant to the people than a machine solely for transportation. Many of the services the helicopter can provide so effectively such as suppressing crime, fire protection, and rescue, will cause helicopters to be allowed even though they are noisier than desirable. However, even for these critical functions, the helicopter must not be a major annoyance. This has been proven particularly in the helicopter law enforcement patrol where the public supports the police helicopter when it is quiet, but protests its presence when it is a continuing annoyance—particularly at night.

	• PATROL • FIRE FIGHTING • BANKING • AIRLINE	• TRAFFIC CONTROL • FREIGHT DELIVERY • CONSTRUCTION • URBAN BUSSING • HIGH RISE/FREEWAY RESCUE
• RESCUE • TRANSPORT		
PAST	PRESENT	FUTURE

Everybody would agree that a quiet helicopter is certainly better than a noisy one. The questions is 'What does it cost to provide the quietening?' We will give some specific results in this paper but they should be preceded by the statement that so little has been done to date in the development of helicopter quietening that one cannot accurately predict the true eventual cost. In the final analysis it will probably take some horsepower or performance reduction from the helicopter to achieve external quietening, as opposed to that same helicopter operating

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in an unquieted mode. However, as has happened so many times in technology development, solutions are found when the need exists that do not compromise the efficiency of the machine.

'QUIET ONE' PROGRAMME

The first significant R & D programme to explore the potential of quietening helicopters was initiated in 1969 by the Advanced Research Projects Agency (ARPA) and the US Army. The most extensive work in this programme was done on the OH-6A, a 317 hp light turbine helicopter with a gross weight of 2400 lb and a payload of 610 lb in addition to pilot and full fuel. This aircraft, known as the Quiet One (Fig. 1), was modified to lower rotor tip speeds, since much of a helicopter's noise is generated by the high velocity of the blade tips which approach the speed of sound. Then to compensate for the reduced rotor thrust available at the slower tip speeds, the main rotor was increased from four to five blades (Fig. 2); and the tail rotor was increased from two to four blades with staggered spacing (Fig. 3). An engine exhaust muffler was also developed (Fig. 4). Other modifications included noise reducing elements such as shrouded engine inlet to suppress main rotor transmission noise, finer tooth gears, sound deadening materials on gears and shafts and special blade tips^(2, 3).

The reduction of sound level with the increase in number of tail and main rotor blades and the reduction in tip speed, is shown in Figs. 5 and 6, respectively⁽⁴⁾. The tests demonstrated that the tail rotor tip speed reduction made the most significant contribution to noise reduction with only an 8 lb weight penalty. With all the noise reduction elements in effect, the external sound level was reduced 17 dB to 20 dB* in hover and 14 dB to 16 dB in level flight. The total weight increase was 192 lb for the changes made, plus some horsepower loss due to the muffler⁽⁵⁾. Since additional engine power and rotor capacity were available in the Quiet One, these losses could be overcome to maintain the original 610 lb payload. Under this flight condition, a 13 dB sound level reduction could be obtained as shown in Fig. 7. The increased power to carry the 192 lb weight increase and compensate for muffler losses is 50 hp. Compared to the standard operation, these changes relate to 32% of payload or 23% increase in horsepower in exchange for a 78% decrease in noise.

*Overall sound pressure level (OASPL).



Figure 1. The 'Quiet One'.



Figure 2. Five-bladed main rotor system.



Figure 3. Four-bladed tail rotor—75° by 105° spacing.



Figure 4. Muffler installation.

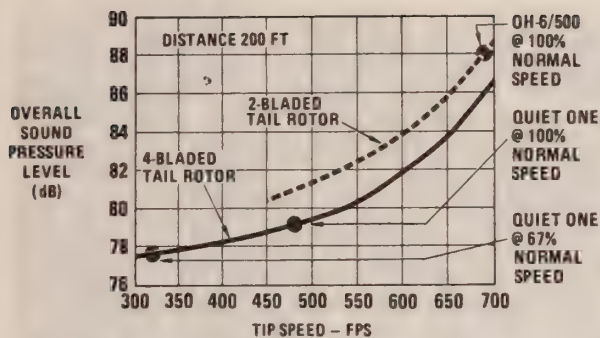


Figure 5. Variation in tail rotor noise with tip speed.

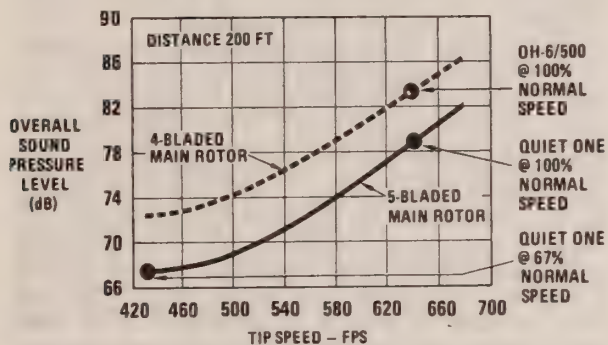


Figure 6. Variation in main rotor noise with tip speed.

The significance of the noise reduction demonstrated is related to how close such a helicopter can operate to residential areas while still not becoming a source of annoyance such as in law enforcement patrol. Figure 8 illustrates the results of a test producing a sixfold reduction in helicopter aural detection distance, varying with engine power settings and gross weight. As shown, a helicopter can operate over a wide range of payloads and gross weight within 1200 ft range and 100 ft altitude of an urban residential area without being heard or it can fly at 500 ft directly overhead and hardly be heard against a background noise level of 65 dB.

An interesting part of ARPA/Army programme was the fly-off of the Quiet One helicopter against the quiet fixed wing aircraft, the YO-3A, Fig. 9. This aircraft was built by the US Army for surveillance work in Vietnam. The comparative testing was accomplished at the Hughes Helicopters flight strip in Culver City, California. It was established that the quiet helicopter was actually quieter



Figure 9. YO-3A quiet aircraft.

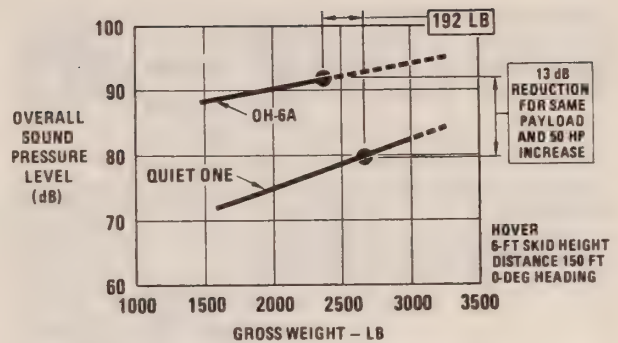


Figure 7. Noise/weight trade-off.

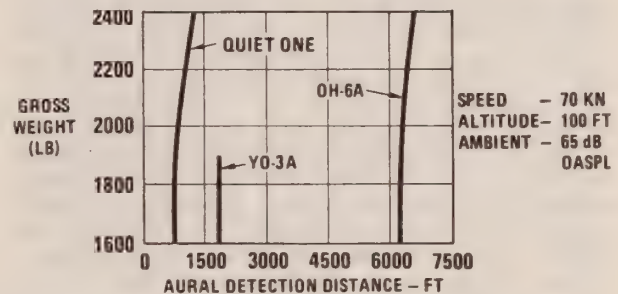


Figure 8. Aural detection range of approaches.

than the YO-3A fixed wing aircraft when judged on the basis of detection range per Fig. 8. Both aircraft were extremely quiet. However, the YO-3A projected forward a higher frequency propeller noise which made it detectable twice as far away than the quiet helicopter.

It came as something of a surprise that the helicopter, generally thought to be inherently noisy, can actually be the quietest of all powered aircraft. This finding has rather far-reaching effects since the helicopter's future is intimately linked to how close it can operate to people.

QUIETENING OBJECTIVES

Having established that helicopters can be quietened from a practical standpoint, the question is 'How quiet do they need to be?' This question is being addressed in actions being taken throughout the world to establish helicopter noise specifications relative to heliport operations.

One of the problems with these quietening specifications concerns the attempts to use existing fixed wing airport noise criteria for heliports. This criteria is identified as an integrated noise level above the background noise throughout a 24 hour day. One method of specification of the noise level is to establish noise contours for day-night noise level (Ldn). 'Ldn' is simply an integration of the various noise events measured in dBA and weighted for duration of peak level and number of noise events. Noise events are penalised tenfold for operations during the nine night-time hours from 22.00 hrs to 07.00 hrs as opposed to 15 'daytime' hours between 07.00 hrs and 22.00 hrs.

The net result of applying Ldn methodology is to establish the number of helicopter flights that may take place in and out of a given heliport throughout the 24 hour period based on the proximity of residential areas to the heliport. Studies of applying the Ldn criteria in-

$$L_{dn} = 10 \log \frac{1}{24} \left[\sum \text{ANTIOLOG} \frac{[HNL]_{DAY}}{10} + 10 \sum \text{ANTIOLOG} \frac{[HNL]_{NIGHT}}{10} \right]$$

$$HNL = 10 \log \left[\sum \left[\left(\text{ANTIOLOG} \frac{dBA}{10} \right) \times \Delta t \right] + \sum \left[\left(\text{ANTIOLOG} \frac{dBA}{10} \right) \times \Delta t \right] - 35.6 \right]$$

TAKEOFF
LANDING

Day-night noise level (Ldn).

dicade that heliport location and utility will be severely restricted if the fixed wing airport Ldn level of 65 dBA or less is specified initially for heliports. In view of the very early technical stages of helicopter quietening, it is recommended instead that the noise criteria for heliports be tapered downward with time, starting from perhaps 75 dBA Ldn at the present time, with the requirement reaching 65 dBA by 1985. In a typical daytime flying operation in a city centre with interspersed residential areas, the more stringent 65 dBA Ldn would have the effect of reducing the number of allowed flights of today's turbine helicopters from 375 flights to 50 flights per 24 hour period. This would make the operation of a downtown public-use heliport uneconomical until the helicopters using the facility could be quietened for take-off and landing.

If this specification approach continues, the heliports required for expansion of urban helicopter operations will not be built. Instead, we need heliport and helicopter in-flight noise specifications which are time-phased to provide a reasonable balance between transportation need, environmental need, and development of the quietening technology. This requires an understanding of the technical status of helicopter quietening by the noise regulators and the expenditure of R & D money to quieten helicopters. To date, in all the world perhaps only \$5 million has been spent in this pursuit.

QUIETENING STATUS

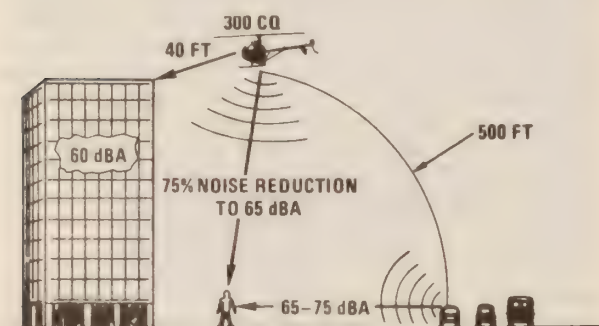
At the present time two basic approaches exist for quietening the helicopter. One is to provide it in the cruise flight mode only, and the other is to provide it throughout the full range of helicopter operation from take-off to flight and landing. Quietening in cruise flight

mode is now in a production helicopter, the Hughes 300CQ. To accomplish this, the US Federal Aviation Administration has approved a reduced rotor rpm of 10% and dual exhaust mufflers for helicopter operation at altitudes above 500 ft and forward speeds above 40 mph. This combination reduces the overall sound pressure level on the ground by 75% to 65 dBA. This sound reduction is important when the helicopter is used in police patrol functions throughout the 24 hour day. Only 20% reduction in payload is required to operate in this quiet mode on this helicopter. When maximum quietening is not required, the option is available to fly at close to full gross weight, with only a 5% reduction in payload (35 lb due to the muffler). Under this condition the helicopter will still be 50% quieter than if no mufflers were used. For reference to the ear, the 300CQ can hardly be heard when flying in its quiet mode at 500 ft above a typical 65 dBA to 75 dBA city background noise.

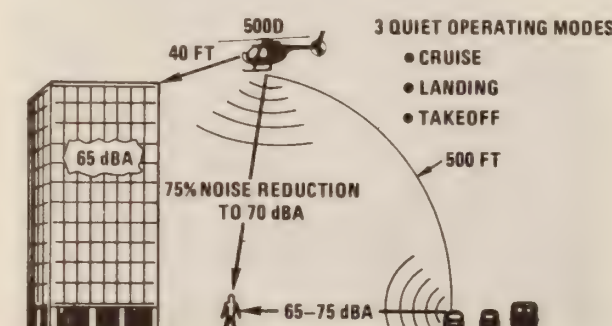
To assure the helicopter's future economical operation at urban public-use heliports, a quiet take-off and landing capability must be added to the helicopter to supplement the quiet cruise mode. This added capability requires the implementation of the technique developed for the Huges Quiet One. The implementation of some of the Quiet One techniques in a production helicopter has been initiated in the Hughes 500D light turbine helicopter. Initially, it will be able to cruise in a quiet mode at the same payload as its predecessor 500C, or fly with a 50% greater payload in a normal mode. The basic quiet operation is achieved by reduced rotor tip speed made possible with the increased number of main and tail rotor blades, as provided in the Quiet One. Under the reduced rotor speed condition, safe autorotation, of course, must be maintained. As all the known quietening features are implemented, this helicopter will be able to offer a 10 dBA to 15 dBA noise reduction or approximately 75% quieter operation at the same payload as the 500C in take-off and landing. In all modes of operation, the 500Ds noise level will be barely perceptible above the city background noise.

One of the advantages of the dual mode capability is that it presents a commercially practical way for quietening to be introduced. In the final analysis, quietening has to be affordable at the same time that it is being required. If it is not, helicopters will have limited operation in the city.

The result of achieving a 75% quieter operation for future light turbine helicopters will permit economical heliport operation. For example, a typical daytime flying operation at 65 Ldn would permit approximately the same 375 flights per day as today's operations at 75 Ldn for unquietened helicopters.



Current 'quiet mode' operation near ambient traffic level.



Future 'quiet mode' improvements.

CITY HELICOPTER NEED

Expanded helicopter use in the cities is much in tune with the need to improve the quality of life in our cities. Perhaps no other invention can do so much as the helicopter in improving our future city environment.

One important aspect is the value of the helicopter in decentralisation. In combination with the computer data link, it is now practical to operate smaller decentralised plants as efficiently as one large plant. Management controls are maintained via the computer data link, and management communication is supplemented by transporting small groups of the management team from plant to plant throughout each day by helicopter. The payoff to the company is potentially reduced labour cost and a more stabilised work force by having their decentralised plants located in the city fringe within a radius of perhaps 50 to 100 miles. The payoff to the plant employee is the reduced transportation cost and the more favourable living conditions. The payoff to the city is the elimination of traffic flow through the city centre, decreasing the need for additional roadways and rapid transit systems. The potential of this approach is evidenced by the fact that the cost of a light turbine helicopter can be offset by as few as 100 employees who would save 20 miles a day each in round trip driving to their work. A decentralised plant of 1000 employees under these conditions would save up to 250 000 gallons of fuel per year as well.

In summary, our objectives in quietening helicopters are to cruise unnoticed at 500 feet above the city and residential areas day and night; and second, to take off and

land at urban heliports with an economically acceptable number of flights per day without unduly disturbing neighbours who are as close as 1000 ft along the flight path and 150 ft to the sides. Both objectives must be achieved with a minimum payload penalty.

To achieve these objectives, Government R & D support is required for quietening programmes. Additionally, there is a need for refinement in noise specification for heliports and practical time phasing of their application. Execution of these tasks will result in achieving the helicopter's quiet capability and its widespread application for improving the quality of life in our cities. The helicopter is ready to help, and it can do it quietly.

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BIOGRAPHYTHOMAS R. STUELPNAGEL

Thomas R. Stuelpnagel is the Chief Executive of Hughes Helicopters. He was appointed Vice President and General Manager in 1971, and was previously the Assistant General Manager since 1967.

Mr. Stuelpnagel is a native of Owatonna, Minnesota, and has been a resident of California since 1940. He graduated from high school in Long Beach, and served in the U. S. Marine Corps during World War II. After the War, he graduated from UC-Berkeley with a degree in Electrical Engineering, and holds a Masters Degree in Electrical Engineering from the University of Washington. He joined Hughes Helicopters in 1946, where he has held a series of engineering and management positions in electronics, weapons, and helicopters.

Mr. Stuelpnagel has been active in the aerospace community throughout his career. He is a Trustee of the Association of the United States Army and Chairman of the Los Angeles Chapter; Director of the American Defense Preparedness Association and First Vice President of the Los Angeles Chapter; and Chairman of the American Helicopter Society. He holds patents and has published numerous articles.

Mrs. Stuelpnagel is the former Shirley Oliver. They have three children -- Richard, John, and Julie. They make their home in Redondo Beach, California.



DEPARTMENT OF THE TREASURY

WASHINGTON, D.C. 20220

ASSISTANT SECRETARY

MAY 17 1976

Dear Mr. Milford:

Thank you for extending to the Treasury Department the opportunity to contribute to the study of civil aviation research and development by the Committee on Science and Technology, Subcommittee on Aviation and Transportation R&D.

The Treasury Department does not have general responsibility for national transportation policy. However, the Department has recently announced an action which will affect the aviation industry, namely to increase the useful lives of aircraft depreciated under the Asset Depreciation Range System. The attached materials describe this action, the reasons for it, and its probable effects.

If we can be of any other assistance, please let me know.

Very truly yours,

Charles M. Walker
Assistant Secretary

The Honorable
Dale Milford, Chairman
Subcommittee on Aviation
and Transportation R&D
House of Representatives
Washington, D.C. 20515

Enclosures

I. Recent Treasury Action

On April 14, 1976, the Treasury Department announced its intention to increase to 12 years the asset guideline period under the Asset Depreciation Range System which taxpayers may elect for aircraft used in contract or commercial carrying of freight or passengers by air. Previously, the guideline period was 6 years. The new period will apply to aircraft placed in service in taxable years beginning after April 15, 1976, unless binding and substantial commitments were made to acquire such aircraft before April 15, 1976.

II. Role and History of Tax Depreciation Policy Generally

Ideally, tax rules for computing annual allowances for depreciation should approximate the real underlying phenomenon of capital consumption. The degree to which this is accomplished has a profound effect on the degree to which an income tax law affects the rate of capital formation. And in the case of specific industries, it will importantly affect the strength of their claim to a share of the economy's resources.

If tax rules result in prepayment of income tax, because an unrealistically low rate of depreciation is allowed, the market rate of return on equities will have to be higher--to pay the additional tax burden and still return investors a rate of return to cover the real cost of investment, including risk. Similarly, if the tax rules result in deferral of income tax by allowing too rapid depreciation, the market rate of return on equities is depressed, for the tax wedge between the investors' return and what must be obtained from operating income has

been reduced.

However, the purpose of tax rules for depreciation measurement is basically not to advantage or disadvantage industry generally, or particular industries. Rather, the purpose is to arrive at reasonable measures of income subject to tax and the timing of its occurrence so that the tax wedge will be uniform over all capital.

The statutory mandate has always been clear. Taxpayers engaged in a trade or business may deduct from gross income a reasonable allowance for the exhaustion, wear and tear, and obsolescence of property. But the development of the rules for depreciation measurement has been, and continues to be, controversial.

Evolution of the measurement techniques has included the "Depreciation Studies" published in the early 1930's which set forth thousands of "useful" lives of particular assets grouped by industry category. Significant increases in depreciation deductions despite decline of income during the depression brought on a rule that shifted the burden of proof to the taxpayer to show that the deductions were reasonable. That policy persisted until 1962. During that long interval the familiar Bulletin F was in force, although its effect was softened by the 1954 introduction of accelerated methods of depreciation. In 1962 the "guideline depreciation" system was set forth, with the ill-fated "reserve ratio test".

All of this evolution, and the accompanying audit controversy over depreciable lives, had the effect, finally, of clarifying an important conceptual weakness that had dogged the administration of tax depreciation rules from the outset. Just as investment is forward looking--we decide whether to invest or not in terms of what we expect the results will be--so should depreciation allowances with respect to the investment be forward looking. Of course, the past is a guide to formulating our expectations, but once made, an investment decision is irrevocable. If our expectations are achieved, we earn the expected return; if our expectations are exceeded, we earn an abnormal return; and if future results fall short of our expectations, we earn a subnormal return, or suffer a loss.

But depreciation allowances were not forward looking in the pre-1971 administration of tax depreciation rules. Under Bulletin F, and more conspicuously under the 1962 Guidelines reserve ratio test, what the taxpayer's experience was--good or bad--would determine what his depreciation allowances would be with respect to investment undertaken currently.

The Asset Depreciation Range System was enacted in 1971. Although the system operates according to a fairly complex set of rules, its essence is simple: the Secretary of the Treasury is authorized to prescribe the guideline period for classes of assets, depending on their industry category and based on actual industry experience; and tax-

payers who elect to use the ADR System are permitted to select a depreciation period within a range from 20 percent below to 20 percent above the guideline period.

Thus, in 1971, when the ADR System was announced, the principal change from what had gone before was a redirection of attention from the past toward the future. With respect to investments made today, the taxpayer electing to use this system is given assurance that, if he uses a depreciation period within the published Asset Depreciation Range, his depreciation deductions will not be subject to administrative change. At the same time, because the depreciation of each year's vintage of depreciable assets is independent of other vintages, it is possible to revise asset classifications and corresponding depreciation periods as expectations of future conditions warrant. To carry out the task of asset classification and the establishment of guideline depreciation periods, the Treasury established the Office of Industrial Economics.

So far as the Treasury Department's own studies and those of independent reserachers are able to show, tax depreciation allowances determined under the ADR System do not depart, on the whole, from the actual depreciation which occurs. These studies imply that straight-line methods do not describe the actual path of depreciation, and they suggest that actual replacement periods are far shorter than accounting methods used by most business firms assume. In some

instances, careful study shows that ADR depreciation allowances permit only a subnormal rate of capital recovery for income measurement purposes; in other cases, indications are that ADR depreciation is excessively accelerated.

Whenever there is an imbalance, and whichever way the imbalance operates, OIE works to correct it. The new guideline period for aircraft was developed as part of this process.

III. Tax Impact of New Guideline Period

The new guideline period will be 12 years, rather than six. However, this will by no means cause a halving of depreciation allowances. First, it must be remembered that taxpayers may choose a depreciation period within a 20 percent range of the guideline period. Thus, the range applicable to aircraft and associated depreciable assets is being changed from 5-to-7 years to 9.5-to-14.5 years. Second, because present law provides that an asset is eligible for a full investment credit only if its depreciable life is 7 years or more, airline companies have typically chosen to depreciate aircraft over 7 years. It is to be expected that under the new guideline period most taxpayers will choose 9.5 years. Therefore, the overall reduction in the annual rate of depreciation will be, not 50 percent, but approximately 25 percent, and this difference diminishes over the life of the asset.

In addition, the new guideline period will apply only to aircraft placed in service in years beginning after April 15, 1976. Depreciation on aircraft already in service will not be affected.

IV. Effect of Change on Airline Cash Flows

Only that portion of the airline industry's annual expenditures for aircraft and related ground support equipment is affected by the proposed change in guideline depreciation period. The expensive investments of airlines in computers, office equipment, structures and related assets do not fall within the affected asset class. As a consequence, the tax impact, and hence cash flow impact, of the change is strictly related to probable replacement and net additions to the aircraft fleet.

Estimation of these affected acquisitions is necessarily tenuous. According to a statement by an industry spokesman, the planned replacement period for jet aircraft is twenty years. Since most of the fleet was acquired in the mid and late sixties, aside from accidental losses, few of the aircraft presently in inventory will require replacement during the next ten years. Additionally, predictions of likely additions based on traffic growth rate projections are clouded by abnormal uncertainties in the wake of market adjustments to the spectacular rise in fuel costs and the concerted aim of the industry and the CAB to raise load factors from their present level.

Nevertheless, ignoring the uncertainties just noted, and assuming a 7 percent annual growth in traffic with no change in load factor, and ignoring certain tax offsets to be noted below, the following table provides estimates of the investment by airlines for the years 1977-1981 and the probable net reduction in total industry cash flow that would result from the change in ADR life. Note that the estimates of cash flow changes ignore increases in operating revenues which may be expected to be realized via regulated fare increases as a consequence of an increase in this category of costs.

Effect on Airline Cash Flow of Increase in ADR Class Life

	<u>Reduction in Cash Flow Due to Change</u>	<u>Estimate of Investment</u>
1977	\$ 5 million	\$0.2 billion
1978	20	0.4
1979	65	1.5
1980	100	1.9
1981	130	2.4

For perspective on the cash flow figures, it helps to observe that, in 1974, which was a disastrous year for airlines, the industry net cash flow was \$1.9 billion.

Offsetting these potential increases in airline company (and their lessors') tax payments are the large carryover of tax losses now on the books along with unused investment credits, some of which would expire in the absence of larger tax liability.

V. Economic Impact of the Change: Effects on Fares

Changing the airline guideline depreciation period from 6 to 12 years will cause the investors in this industry to increase their effective tax depreciation period from 7 to 9.5 years. Viewing the affected investment prospectively, this change has the effect of increasing the total cost of obtaining the services of aircraft, i.e., there will be an increase in the cost per seat-mile of providing aircraft and associated equipment sufficient (a) to compensate investors at the CAB 12 percent rate of return, (b) to cover replacement cost, and (c) to pay income taxes.

Under present law, the estimated total capital cost per seat-mile in the sense just described is 0.802 cents. After the proposed change, this will rise to 0.833 cents, an increase of just under 4 percent.

Of course, the service purchased by airline customers must not only cover this element of cost but also labor, fuel, and other operating expenses. Presently, these noncapital costs of airline service amount to 2.644 cents per seat-mile. Thus, under present law, the total cost per seat-mile is 3.446 cents, and after the proposed change it will become 3.477 cents, an increase of 0.9 percent.

The probable effect of the proposed change is, therefore, to cause the level of future airline fares to be 0.9 percent higher than they otherwise would be. Put another way, under present law, airline users are subsidized by the tax system by approximately 1 percent of their present fare levels.

VI. Economic Impact of the Change: On Aircraft Lessors

At the present time, approximately 35 percent of the aircraft held by certified carriers is leased by them. Transportation companies have traditionally financed their acquisition of vehicles by collateral trust bonds or by leasing them. This practice derives from the obvious fact that individual vehicles have determinate resale value, require little cost to repossess, move, and resell, and thus constitute excellent collateral for lenders.

In any case, whether a vehicle is leased by an airline, or financed by it through borrowing, the only consequence is whether the asset appears in the balance sheet of the lessor or of the airline. In either case, the aircraft must earn enough gross revenue to compensate its owner, finance its replacement, and pay taxes. Thus a change in depreciation rules has the same economic effect on usage of vehicles whether the user is the owner or a lessee. The proposed change in the aircraft guideline life (which applies to the lessor as well as the owning airline) increases by about 4 percent the annual "rental" of an aircraft if it is leased, the same amount by which the earnings of the airline would have to increase if it owned the vehicle.

It is also not uncommon that leasing syndicates are formed in order that the tax attributes inhering in the legal "owner" of the aircraft will come to rest in the hands of individuals in relatively

- 10 -

high income brackets. Although this practice was sharply limited by the Tax Reform Act of 1969, it still persists. The proposed lengthening of tax depreciation lives causes a larger reduction in tax benefits for such lessors than for ordinary corporate lessors (banks, etc.). It is therefore predictable that this kind of leasing arrangement will be made less attractive. But the advantage of standard leasing arrangements, such as those involving financial institutions, and conventional equipment leasing firms, relative to purchase by the airlines, will be little affected. More to the point, to the extent that the need for off balance sheet financing by the airlines is reduced, presumably the demand for conventional financing from the same lending institutions will increase.

The Department of the **TREASURY**

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NEWS

FOR IMMEDIATE RELEASE

March 24, 1976

ASSISTANT SECRETARY WALKER ANNOUNCES REVISED ADR GUIDELINES

Charles M. Walker, Assistant Secretary of the Treasury for Tax Policy, today announced publication of revised asset guideline classes, depreciation periods, and repair allowance percentages applicable to the textile industry.

Addressing the Board of Directors of the American Textile Manufacturers Institute in San Francisco, Mr. Walker said the revised guidelines were derived from a recently completed study of the textile industry by Treasury's Office of Industrial Economics.

In his remarks, Mr. Walker cited the cooperative efforts of the Office of Industrial Economics, textile manufacturing companies, and the American Textile Manufacturers Institute in assembling information on historical asset replacement patterns, and the probable effects on these of emerging and technological and market conditions.

Terming completion of the study and publication of the revised guidelines a "landmark event" in tax policy, Mr. Walker said that it demonstrated that the Treasury Department is responsive to changing conditions which affect American industries. Treasury is determined to make the Class Life Asset Depreciation Range system a viable and up-to-date mechanism for attaining neutrality, practicality, simplicity and equity in the determination of depreciation charges for the purpose of measuring the tax base of economic income, he said.

Mr. Walker stated that the cooperative spirit in which the study was conducted should serve as a model for subsequent studies of other manufacturing industries for revision of depreciation guidelines.

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WS-736

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NEWS



FOR IMMEDIATE RELEASE

ADDRESS BY THE HONORABLE CHARLES M. WALKER
ASSISTANT SECRETARY FOR TAX POLICY
BEFORE THE
AMERICAN TEXTILE MANUFACTURERS INSTITUTE
SAN FRANCISCO, CALIFORNIA
MARCH 24, 1976

It is a pleasure to meet this morning with the Board of Directors of the American Textile Manufacturers Institute. As you represent one of the Nation's basic industries, I am particularly pleased today to bring you some good news. I understand that you will be discussing such topics as prospective trends in textile markets, and the effects on them of imports, Federal energy policies, and the spread of Government regulation. Some of these subjects relate to what the Government is doing to the textile industry, and they will doubtlessly give rise to requests that something be done for the industry. Happily, I am able to announce today completion of a project the Treasury Department has done with the industry, and because the aim of the project was to do what is right under the Internal Revenue Code, I think we may all be proud of what has been accomplished.

The project I refer to is a 2-year study of conditions bearing on the guideline classes, lives, and repair allowance percentages appropriate for the textile industry under the Class Life ADR System. Individual textile firms and the Institute fully cooperated with Treasury's Office of Industrial Economics in the execution of the study; and I trust you will have found that Office was receptive to inputs your industry has provided. The result of this extensive effort has been embodied in the publication today of a Revenue Procedure (Rev. Proc. 76-17) setting forth revised asset classifications and corresponding guideline depreciation periods and repair percentages. We believe that these elements of tax policy bearing on the textile industry fairly portray the economic attributes of a modern and vigorously progressive industry capable of holding its own in world markets.

WS-737

- 2 -

But the importance of this study transcends the fine work it has accomplished, for it represents the first industry-wide fulfillment of Treasury Department promises that tax depreciation procedures would be continuously monitored and revised with the aim of assuring that taxable income is reasonably measured. In this respect, the Revenue Procedure published today is a landmark in the continuing evolution of income tax law administration. A brief review of the role of tax depreciation policy and its history will help in understanding the significance of the occasion we mark today.

From the beginning, the Federal income tax has included income from capital in its base, whether that income is paid out in the form of interest or accrues as profit. Measurement of the share of private income from capital paid out in the form of interest has presented a minimum of difficulty, for loan transactions carefully stipulate conditions of repayment which permit the segregation of interest income from return of principal. But, since only the income generated by the use of assets financed by debt is formally determinable, the residual, which is profits, absorbs all the error in measurement of the income flow from employment of all the assets. This has a consequence to which I will return later.

Consider the mechanics of business income measurement. Gross income from sales of product is a quantity subject to little controversy in measurement. And the current deductions from gross income, to measure the cost of labor and material services used-up in its production, is only a little more controversial, due to its involving some inventory valuation issues that are difficult to resolve. Thus, what is normally termed "operating income" is reasonably determinable by objective rules of measurement. But the part of operating income which is net income flowing from the enterprise, and which is to be divided between the creditors who receive interest as their share of the reward for financing the acquisition of assets, and the remainder which is the return to equity suppliers, can only be determined by subtracting from operating income an allowance for the value of the enterprise capital which has been used-up during the period. If this allowance is too small, the measure of net income flowing from the assets will be overstated; and since the creditors' share is contractually determined, the profit share will include all the overstatement. If the allowance for the value of capital used-up is too large, profits are perforce understated.

I know from my own experience that corporation financial managers, and investment analysts serving the capital markets devote a significant fraction of their time to agonizing over the vexatious issues of income measurement posed by the annual allowance for capital used-up--depreciation. They are aware that the measure of depreciation produced by mechanical application of arithmetic procedures is but a first approximation of actual capital consumption. It needs to be adjusted by subjective evaluation procedures to account for inflation, past investment errors--or good fortune--to arrive at a measure of net cash flow attributable to operations. Yet, they may take comfort in their use of mechanical procedures in the knowledge that those procedures will have no long-term practical consequences. An enterprise is not bound by law to pay-out currently the "profit" reported for a year: if the "profit" is overstated, less may be paid-out without unduly limiting the ability of the enterprise to finance capital maintenance and expansion programs. And if "profit" is understated by the consistent application of accounting rules, pay-outs can normally be increased. In the long-run, corporate financial policies and the market prices of equities established in capital markets adjust for aberrations introduced in financial statements by mere accounting method.

However, in the presence of income taxation, the allowance for depreciation used in computing taxable income has real financial consequences. If the tax rules for measuring depreciation result in systematically too slow a rate of capital recovery, the result is systematically to reduce the profitability of equity investment; taxes on the income attributable to equity are, in effect "prepaid" and the cost of this must be reflected in the equity share. Conversely, if the tax rules result in too rapid a rate of capital recovery, taxes on the equity share of income are deferred; indeed, in the extreme, a 1 year write-off of capital expenditures relieves from tax all income from depreciable capital.

Ideally, tax rules for computing annual allowances for depreciation should approximate the real underlying phenomenon of capital consumption. The degree to which this is accomplished has a profound effect on the degree to which an income tax law affects the rate of capital formation. And in the case of specific industries, it will importantly affect the strength of their claim to a share of the

economy's resources. If tax rules result in prepayment of income tax, because an unrealistically low rate of depreciation is allowed, the market rate of return on equities will have to be higher--to pay the additional tax burden and still return investors a rate of return to cover the real costs of investment, including risk. Similarly, if the tax rules result in deferral of income tax by allowing too rapid depreciation, the market rate of return on equities is depressed, for the tax wedge between the investors' return and what must be obtained from operating income has been reduced. Parenthetically, this is why industry representatives continually petition for an "acceleration" of tax allowances for depreciation. They sense that if they could reduce the tax wedge their industry must bear, they would be able to attract more equity at the going rate of return.

But the purpose of tax rules for depreciation measurement is basically not to advantage or disadvantage industry generally, or particular industries. Rather, the purpose is to arrive at reasonable measures of income subject to tax and the timing of its occurrence so that the tax wedge will be uniform over all capital. We may wish that our tax system did not include this wedge, for it means that our national capital stock is probably lower than it would otherwise be; but until Congress amends the Internal Revenue Code to eliminate income from capital from its base, and so remove the bias against saving and investment, the responsibility of the Treasury Department is to help develop rules to measure that income so it may be taxed as prescribed by law.

The statutory mandate has always been clear. Taxpayers engaged in a trade or business may deduct from gross income a reasonable allowance for the exhaustion, wear and tear, and obsolescence of property. But the development of the rules for depreciation measurement has been, and continues to be, controversial.

Evolution of the measurement techniques has included the "Depreciation Studies" published in the early 1930's which set forth thousands of "useful" lives of particular assets grouped by industry category. Significant increases in depreciation deductions despite decline of income during the depression brought on a rule that shifted the burden of proof to the taxpayer to show that the deductions were reasonable. That policy persisted until 1962. During that

- 5 -

long interval the familiar Bulletin F was in force, although its effect was softened by the 1954 introduction of accelerated methods of depreciation. In 1962 the "guideline depreciation" system was set forth, with the ill-fated "reserve ratio test".

All of this evolution, and the accompanying audit controversy over depreciable lives, had the effect, finally, of clarifying an important conceptual weakness that had dogged the administration of tax depreciation rules from the outset. Just as investment is forward looking--we decide whether to invest or not in terms of what we expect the results will be--so should depreciation allowances with respect to that investment be forward looking. Of course, the past is a guide to formulating our expectations, but once made, an investment decision is irrevocable. If our expectations are achieved, we earn the expected return; if our expectations are exceeded, we earn an abnormal return; and if future results fall short of our expectations, we earn a subnormal return, or suffer a loss. But, each year, as we contemplate the desirability of investment, the price we must pay for the assets should be independent of the price--that we might have paid for investments in prior years. By-gones are by-gone.

Not so in the pre-1971 administration of tax depreciation rules. Under Bulletin F, and more conspicuously under the 1962 Guidelines reserve ratio test, what the taxpayer's experience was--good or bad--would determine what his depreciation allowances would be with respect to investments undertaken currently.

Therefore, in 1971, when the ADR System was announced, the principal change from what had gone before was a re-direction of attention from the past toward the future. With respect to investments made today, the taxpayer electing to use this system is given assurance that, if he uses a depreciation period within the published Asset Depreciation Range, his depreciation deductions will not be subject to administrative change. At the same time, because the depreciation of each vintage of depreciable assets is independent of other vintages, it is possible to revise asset classifications and corresponding depreciation periods as expectations of future conditions warrant. And recognizing that this system of tax depreciation administration puts a heavy burden on asset classification and realistically

- 6 -

establishing guideline depreciation periods, the Treasury established the Office of Industrial Economics to monitor the system continually and to recommend changes in its parameters as needed.

This promise to reexamine the bases for tax depreciation policy had been made many times before, but was not a promise faithfully kept. Studies tended to be made, guidelines published, not before the need for change had become manifest, only after the fact. This was true in 1931, 1942, and 1962. But today we have kept the promise, and with you, we celebrate the completion of an industry wide study and the implementation of a current revision which will bring the textile industry into line with prevailing conditions.

From its establishment in 1971, the Office of Industrial Economics has striven to carry out the mandate of its charter professionally and with dispatch. Its role is not to establish an arbitrary capital recovery rate for each industry. Rather, it must rely upon determinations based in part on past and forecast capital asset acquisitions and replacement rates, and a consideration of technologic and economic forces operating on those replacement rates.

In its studies, in the spirit of forward-looking investment policy, OIE thus emphasizes the future. In the spirit of the Class Life System, OIE examines investment policy from the perspective of an industry, not the pre-1971 perspectives of the facts and circumstances of individual taxpayer's acquiring isolated items of depreciable property. For this reason, OIE is organizationally within the Office of Tax Policy. This provides OIE an environment free of adversary confrontations and facilitates the cooperative pursuit of analytically valid conclusions derived from governmental and private sources.

While we all can rightfully take pride in the evidence we have that the system of tax depreciation administration is now working, in all candor I must acknowledge that pressures are building, in Congress and elsewhere, to legislate blanket changes in the Class Life System. Many regard the range of 20 percent above the asset guideline depreciation period as a kind of "giveaway", which they would repeal. The ceaseless stream of studies based on financial reports of corporations which purport to show that the "effective" rates of corporation income tax are low reinforces the layman's belief that tax depreciation allowances presently permitted are "phony".

- 7 -

Ironically, most of the cases of artificially accelerated capital recovery allowances and related investment preferences are those which Congress has enacted and which are not a part of the Class Life System. I refer specifically to the tax treatment of real estate, minerals, timber, and investment in anti-pollution equipment, railroad rolling stock, rehabilitation of housing, and others.

So far as our studies and those of other independent researchers are able to show, tax depreciation allowances determined under the Class Life System do not depart, on the whole, from the actual depreciation which occurs. These studies imply that straight-line methods do not describe the actual path of depreciation, and they suggest that replacement periods are far shorter than accounting methods used by most business firms assume. In some instances, careful study shows that ADR depreciation allowances permit only a subnormal rate of capital recovery for income measurement purposes; in other cases, we have indications that ADR depreciation is excessively accelerated. If we are willing to revise upward depreciation rates which are too low, so should we be willing to revise downward those which are too rapid. To keep the system working, we need the support of informed opinion, both when we make the former kind of revisions, and also when we make the latter.

This brings me to my final remarks, which are intentionally sober to balance the optimism of my earlier statements. There is a practical limit of the extent to which the Treasury and the Congress can proceed in reasonably measuring taxable income. That limit is, simply stated, not too far from the practice you in industry follow in your financial accounting. The ordinary citizen simply cannot understand why depreciation for financial reporting should be substantially less than the depreciation deductions taken for tax purposes. They perceive this as one of the principal causes of low "effective" tax rates paid by business. The existence and growth of "deferred taxes" reported on financial statements of corporations is tantamount to a public declaration that tax depreciation rules do result in tax deferrals and low effective tax rates. While I should be surprised to find corporate financial managements uniformly in accord with tax depreciation rules, it must be a matter of deep concern to all of us when large resulting differences in tax and financial income persist. Hopefully, the new textile industry depreciation will help close whatever gap now exists between financial and tax accounting attributable to depreciation deductions.

Thank you.

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IS THERE A CAPITAL SHORTAGE?

Remarks by

Henry C. Wallich
Member, Board of Governors of the Federal Reserve System

at the

International Monetary Conference
Session II: Capital Requirements and Capital Sources

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Concern about an impending capital shortage has become widespread. A variety of studies of investment requirements over the next five or ten years, of the adequacy of private and public savings and financial arrangements for converting these savings into investment have already been completed. The generality of this concern attests to the importance of the issue.

There are indeed reasons for posing these questions. The experience of the last few years has confronted us with the limits of our capacity to produce. That same experience has shown us that there are limits to our capacity to finance. Meanwhile new demands are being made on our economies. Important decisions may lie ahead -- to increase our efforts to provide resources or to cut back our aspirations. Failure to make the right decisions may lead to economic imbalance, with the risk of more inflation, insufficient jobs, disappointing living standards.

In examining the requirements for new capital, it becomes immediately apparent that the answer differs among countries. The rate of investment and of savings, relative to GNP, varies widely. It runs from about 15 per cent in the United States to close to 40 per cent in Japan. Net savings differ even more dramatically, running from 5 per cent in the United States to 25 per cent in Japan. A flow of investment and saving that might be perfectly adequate in one particular country might bring the economy of another to a grinding halt. What matters is not the level of these flows, but their relationship to the structure of individual economies, to the levels maintained in the past, and to the requirements of a future that is bound to be, in large measure, a continuation of that past. For that reason, my comments are addressed principally to the United States. Some of the data appended, however, will also serve to provide a comparison of the U.S. with other countries. (Tables 1 and 2)

Tests of Capital Adequacy

Capital inadequacy can show up in various forms. First, it may manifest itself in bottleneck situations, with some industries having adequate capacity for high-level operation of the economy and others not having enough capacity to supply the needs of consumers and of other industries when they all operate at a high level. Frequently this is a problem of bottlenecks for raw materials and industrial materials. But it also affects more highly finished goods. In the

-3-

United States there probably is a good deal of this capital inadequacy, as the shortage experience of 1973 and 1974 indicates.

It should be borne in mind, however, that the pattern of demand may shift and that the past is no exact guide to the bottle-necks of the future. In a worldwide economy, moreover, insufficient supplies in one country can often be met from abroad, unless the unusual synchronization of cyclical peaks experienced in 1973-74 is repeated.

Second, an over-all shortage of capital with respect to the labor force is possible, even if capacity is fairly evenly distributed among industries. There would then not be enough jobs to provide full employment even when industry is operating close to capacity. This condition, too, I believe to prevail in the U.S. as a result of inadequate past investment.

Capital capacity, in other words, seems to fall short of labor force capacity. This is a serious condition which labor has as urgent an interest to remedy as has business. The peak of labor force growth, reaching 2.4 per cent during the five years 1970-1974, seems to be behind us, but projections for the remainder of the 70's and for the early 80's still show labor force growth in the range of 1.6-1.8 per cent per year.

When capital shortages of the two types described so far are not present, one really cannot speak of a shortage of capital. That would be true not only of the United States, but of any other

-4-

economy. However, a society can be dissatisfied with its total supply of goods, or with the rate of growth of that supply. Social strains, or inflation, could be evidence of such a condition. Alternatively, a society may be willing to accept a low rate of growth but may find itself falling behind economically and politically. This condition could be remedied by a more ample supply of capital, if the nation so chose. There is some doubt, however, how much of an acceleration of growth can be accomplished by increasing the supply of capital when other factors of production increase at an unchanged rate.

Another test of capital adequacy is the rate of return on capital. In the U.S. this rate of return has declined severely when properly adjusted for inflation. This would suggest that the demand for capital is low. However, the rate of return measures the average productivity of capital, not its marginal productivity. It is quite possible that average productivity has been depressed by the many adverse factors that have impinged on business -- international competition, strength of labor unions, inflation, widespread hostility to business, government regulation and taxation. Meanwhile, the return on capital at the margin, i.e., for new investment, may nevertheless have risen. This would seem to be indicated by the willingness of business to borrow at very high interest rates and sell new equity even on adverse terms.

The Demand for Capital

In the U.S. there is no shortage of capital in the short run. There is enough excess capacity materially to increase production. But absorption of this existing excess capacity, important as it is, constitutes a short-run problem. Concern over the adequacy of the stock of capital and its growth through investment pertains to the medium and longer run. In that perspective, it becomes necessary to take into account, in addition to the possible inadequacies already existing, the emerging new demands for capital. Some of the investments for which demand is rising are of a kind that will not add much if anything to output. At the same time, there may be other areas of investment where prospective demands promise to abate.

Areas in which demand for capital is clearly rising include: (a) environmental investment, which is largely unproductive; (b) health and safety investment, which contributes to productivity at best indirectly; (c) mass transit, which promises to contribute to over-all growth by reducing the need for less efficient modes of transportation; and (d) energy investment, which will in some regards be a drag on the economy because relatively expensive energy will be substituted for cheap imported oil.

On the side of diminishing demand one may count: (a) investment in housing, as population growth slows down and as housing construction, owing to its very high cost, shifts increasingly from the customary

-6-

single-family home to apartment house dwellings and mobile homes; (b) various forms of nonresidential construction such as schools, where a rapidly declining birth rate is reducing requirements; and (c) inventory investment, the need for which, one may hope, will be held down as better control methods are developed and as inflation abates.

The great bulk of investment in the American economy is private investment, and the largest part of this is investment made by business firms. Gross private domestic investment has been fairly stable historically in the neighborhood of 15 per cent of GNP, with a slight dip during the 1960's and a slight rise in the early 1970's. Within this total, business fixed investment has averaged close to 10 per cent of GNP, with a rising tendency over the last 10 years. This rising tendency becomes even clearer when the data are stated in constant instead of current dollars. Most of the areas of rising investment demand -- environmental, health and safety, energy -- are also in the business sector. Only inventory offers an opportunity here for an easing of demand.

Thus, it is business investment that must be our principal concern. Among the various studies of capital requirements there is a remarkable degree of agreement that nonresidential investment, as a fraction of GNP, will have to average 11-1/2 per cent contrasted with an historic 10-1/2 per cent. It is principally to take care of

-7-

this increase that the necessary savings and financing techniques must be found. Taken by itself, this is not a very large amount. The demand side of the saving-investment process seems to generate no insuperable problems. This, however, is not so on the supply side.

The Supply of Savings

It is on the supply side of the saving-investment process that adverse changes have occurred and where remedies need to be applied. Historically, savings rates in the United States, over the past 20 years, have fluctuated within a narrow band for both households and businesses. Personal savings have ranged from 3.4 to 5.7 per cent of GNP, business savings, including depreciation between 10 and 12 per cent. Typically, there has been some compensatory movement, so that the sum has ranged around 15-16 per cent of GNP.

Consumer savings have been remarkably insensitive to inflation. Apparently, the frequently predicted tendency of inflation to diminish saving incentives has been approximately compensated by a desire of households to maintain some prudent relationships between wealth and income. In fact, the savings/GNP ratio has been near the top of its 20-year range for the past three years. There is little reason to expect it to rise further.

Business saving has suffered severely from inflation. Inventory profits have been very high but these profits are of questionable value to their owners. They generate no cash flow,

-8-

are not available for investment or dividends, and they do generate a tax liability. Likewise, an adjustment must be made for depreciation that is based on original instead of replacement cost. When these two adjustment factors are deducted from corporate profits, a case can be made that domestic nonfinancial corporations did not earn their dividends in 1974. In other words, this dominant component of the American corporate universe, excluding only financial corporations and foreign subsidiaries, can be said to have had negative net savings.

Some qualifications are required in making this case. Inventory profits, after all, are not altogether valueless. Moreover, corporations also have some benefits from accelerated depreciation methods. Finally, since interest is wholly tax deductible, corporations have the advantage that the tax on the inflation premium is paid by the bondholder, not the corporation.

Inflation is not the only cause of declining business saving. The decline in the rate of return, which was mentioned earlier, can hardly be attributed to inflation alone. Hence there can be no assurance that an ending of, or, much less desirably, an adjustment to continued inflation would restore profits to their historic proportion of GNP. Yet a return to this historic proportion is one of the essential conditions of an adequate flow of savings. The other, and indeed crucial condition, is a better saving performance on the part of government.

-9-

Historically, government has sometimes been a net supplier of savings, through debt repayment, and sometimes a net user. The saving or dissaving of the Federal government and of State and local governments sometimes have moved in opposite directions, partly compensating each other's effect on the total savings flow. During the last few years, both the Federal and State and local governments have been net borrowers.

In periods of recession, the danger that government borrowing may crowd out a substantial volume of private sector borrowing is small. The danger mounts, however, as recovery proceeds. Once full employment is reached, obviously any resources that government draws on to itself must lead to a reduction of resources available to the private sector, other things equal.

The stance of government at full employment, whether a net supplier or demander of savings, can be estimated on the basis of the high employment surplus or deficit. Since the early 70's, this computational variable has fluctuated around an average of approximately zero. At the present time, it shows a moderate deficit. The projection shown in the Fiscal 1976 Federal budget shows it rising rapidly to a level of \$61 billion by 1980.

If this projection had probability, the outlook for an adequate flow of savings would be very good. The projection, however, is the result of its assumptions. Continued moderate inflation is

-10-

expected to push taxpayers into higher tax brackets, and this substantial rise in the effective tax burden is not expected to be counteracted fully by tax cuts. Likewise, the projection assumes only moderate expenditure increases and few new spending initiatives.

History provides ample reason to question both assumptions. The effects of inflation on tax brackets have already been compensated repeatedly by tax cuts, principally in 1969 and 1975. A slowdown of government expenditures is more desirable than probable. Meanwhile, the trend of State and local affairs, where there is less fiscal flexibility, suggests that deficits in that sector will continue. A Federal surplus of some magnitude would therefore be required merely in order to get the public sector as a whole into a zero deficit position. A substantially larger surplus would be required to offset the shortfall of savings below expected investment in the private sector, once the economy returns to high employment.

Constraints in Financial Markets

The uncertainty about the future over-all flow of savings noted in the previous section is compounded by constraints that may appear in the financial markets. For many years now, the capital structure of corporations has moved in the direction of a higher share of debt relative to equity. This appeared to be the way to maximize profits at a time when credit was readily available and borrowers' ratings went unchallenged.

-11-

The events of the last few years have changed that picture. Borrowing became less easy, and credit ratings were tested. In good part the consequence was not a shift toward more equity financing but toward more debt in short-term form as longer term financing became less easy. (Table 3) Now the need for a stronger equity component in corporate capital structures has become pressing. Yet internal generation of equity has become more difficult while external financing is suffering from the relatively low level of stock market prices.

Another change may affect the role of banks in the financial picture, which had expanded in recent years. Banks have become increasingly cautious, partly as a result of past over-expansion and mounting risk, partly because of a generally declining capital position. Thus the role of banks in the financing of investment may be more limited.

The stock market, too, has become a less productive source of funds, owing to diminishing buyer interest. Individuals have been net sellers of equities for many years. Of late, the interest of institutional investors also has shifted in some degree away from equities and toward bonds.

Another financial constraint is the level of the money supply. A rapid expansion of the money supply would run the risk of engendering inflationary expectations that by themselves might raise interest rates

-12-

and choke off financing. A more moderate growth of the money supply, on the other hand, consistent with a gradual return to price stability, limits the banks' ability to contribute to the flow of financing.

Review of Studies of Capital Requirements
and Availability of Savings

Studies of capital adequacy, as noted earlier, abound. A few of them are compared in an attached table. Their selection implies no intention to downgrade others that are not mentioned. Those chosen predominantly arrive at the conclusion that there will be no shortfall of savings. That selection was made because this paper questions the conclusion.

After removing the multi-billion-dollar tags from the estimates by expressing all amounts as per cent of GNP, it appears that the investment requirements projected in the different studies are not very far apart, ranging from 15.5 per cent to 16.4 per cent of GNP. It is in the projection of savings that larger differences show up, the range being from 14.2 to 16.4 per cent of GNP.

There is surprisingly little difference among projections of business saving. The principal uncertainty, inevitably, attaches to projections of government savings. By a slight majority, the projections incline toward a very small government surplus, combining Federal and State and local budgets. If the expectation of a State and local deficit is correct, this implies a more sizable Federal surplus.

The most extensive examination of investment requirements and savings flows is that by Duesenberry and Bosworth, about to be published by The Brookings Institution and summarized by Professor Duesenberry in his testimony before the Ways and Means Committee of the House of Representatives in January 1975. This study concludes that we can avoid a capital shortage, "but just barely." The basis for this conclusion is a substantial Federal surplus of 1.3 per cent, equal in the terminal year 1980 to \$31.7 billion. For the private sector alone a deficiency of savings of one per cent of GNP, or \$23.7 billion is arrived at. The Duesenberry-Bosworth study goes farthest in making the point that is common to all studies: avoidance of a capital shortage depends crucially on getting the Federal budget under control.

Tax Remedies

Several studies of capital requirements feature proposals for tax reform designed to increase the flow of saving. Typically they involve measures that would affect the distribution of income as well as reduce the Treasury's revenue. In the second regard, at least, such proposals may be counterproductive by increasing the Treasury's borrowing needs. A more moderate but perhaps less controversial device may be mentioned here. It focusses upon improving the capital structure of corporations.

-14-

Even if an improvement in budgetary posture makes over-all capital flows adequate, problems of corporate debt capacity and equity financing remain. The debt problem is in good part the result of the fact that interest is tax deductible while corporate profits retained or paid out in dividends are taxed to the corporation. A tax structure that would place the same burden on all three forms of disposing of net operating income -- interest, retentions, and dividends -- would avoid this bias and would facilitate and encourage equity financing. The tax rate could be so set as to produce the same revenue as the present tax structure, if a reduction of the tax burden of corporations should prove economically or politically impractical.

Such a tax structure could not be introduced overnight, because it would drastically change the relative position of corporations with high and low indebtedness. But it could be applied to corporate debt and equity created in the future, if the necessary safeguards against loopholes can be built in. Alternatively, the revised tax structure could be phased in gradually, giving firms an opportunity to modify their capital structure over time. The result, I believe, would be easier financing and stronger credit.

Capital Imports and Exports

There can be no doubt that there is at least a possibility of a serious capital shortage in the United States. Whether it will materialize depends very largely upon whether Congress can avoid deficits

in the Federal budget and even achieve a surplus. Resolving the capital shortage problem by means of better budget policy would be by far the preferred solution. Should this solution not materialize, the United States will have to ask itself to what extent, if at all, it can still perform as a capital exporter. The United States ceased to be a net capital exporter when the current account went into deficit in the late 60's. The high cost of oil imports probably has had the effect of preventing the U.S. from becoming once more a capital exporter, although it should be noted that the U.S. current account deficit is small relative to what might be considered to be the appropriate share of the U.S. in the aggregate deficit imposed upon the oil-importing countries by the oil-exporting countries. As the oil problem comes into balance, the U.S. will have to ask itself very seriously whether it would be advantageous to remain a capital importer.

Summary and Conclusions

(1) There is a distinct possibility that a capital shortage may appear in the United States, once the economy moves back to a high level of economic activity.

(2) Higher demands for capital are ahead, mainly as a result of prospective increases in environmental, energy, health and safety, and mass transit investment. These increases probably will be compensated only in part by relatively modest declines in the share of housing and perhaps of inventory accumulation in total investment.

-16-

(3) The principal threat of a shortage of investment funds arises, not from increases in demand, but from uncertainty about the adequacy of savings. One source of uncertainty is the decline in corporate profits that becomes apparent once realistic accounting methods are employed. Another is the apparent trend of the Federal as well as of State and local budgets toward larger deficits.

(4) Studies that conclude that there will be no capital shortage appear to rely heavily on the assumption that the Federal budget will be in surplus and will be supplying capital to the private sector. Continuation of the Federal financing patterns of recent years would do little to make this hope come true.

(5) In addition to the possibility of an over-all capital shortage, business may experience constraints in its financing because of the existing heavy burden of debt, especially short-term. In order to strengthen the equity base and facilitate financing, it is suggested that the method of taxing corporations be shifted gradually, without loss of revenue, in the direction of taxing income used to pay interest while reducing the present tax on the portions of income used to pay dividends and retained in the business.

TABLE 1a.--Gross Saving, 1970-72, Annual Average

	Per cent of GNP	
	Japan	U.S.
Households ^{1/}		
Net saving	13.5	5.3
Depreciation	3.3	3.2
Corporations		
Net saving ^{2/}	5.8	1.5
Depreciation	8.6	5.8
Total private		
Net saving ^{2/}	19.3	6.8
Depreciation	11.9	8.9
Government ^{3/}		
Net saving	7.3	-1.0
Depreciation	1.0	--
Statistical discrepancy	-1.2	-0.4
Total gross saving	38.2	14.3
Total net saving	25.4	5.4

Source: Henry C. and Mable I. Wallich, "Money and Banking in Japan," in Asia's New Giant: How the Japanese Economy Works, Brookings Institution, forthcoming, 1975.

1/ Includes households, private unincorporated business and private nonprofit institutions.

2/ Includes inventory valuation adjustment.

3/ Government and government enterprise.

TABLE 1b.--Household Savings as Per cent of Disposable Income
1960, 1970-7 , for Selected Industrial Countries

	1960	1965	1970	1971	1972
Japan	19.2 ^{1/}	17.5	20.7	20.2	21.0
Germany	15.0	15.9	16.7	15.0	15.1
France	9.7	11.1	12.7	12.3	12.1
United States	4.9	6.0	9.0	9.0	7.2
United Kingdom	4.7	6.1	5.2	4.9	5.0

1/ 1961.

Note: Definitions differ from those underlying national statistics; ratios, therefore, also will not be the same as derived from national sources. Disposable income includes households and private nonprofit institutions serving households.

TABLE 2.--Savings and Savings Rates in Selected Industrial Countries

		Savings as Per cent of GDP			
		Corporate	Government	Household	Total ^{1/} GDP ^{2/}
Germany:	1961	6.0	7.8	5.5	19.3 333.4
	1965	4.5	5.0	7.7	17.3 462.0
	1969	3.4	6.1	7.9	17.3 605.7
	1970	3.7	5.8	8.4	18.0 687.0
	1971	2.4	5.5	8.3	16.2 762.5
	1972	1.9	4.6	9.1	15.5 834.6
	1973	1.2	6.1	8.4	15.7 930.6
France:	1961	3.3	4.0	6.4	13.7 328.2
	1965	2.9	4.8	7.6	15.3 489.0
	1969	4.6	4.9	6.8	16.3 722.8
	1970	3.7	4.9	8.3	16.9 808.2
	1971	3.9	4.5	8.2	16.6 898.9
	1972	3.8	4.4	8.1	16.3 1001.9
	1973	3.7	4.3	8.6	16.7 1146.2
U.K.:	1961	4.4	0.9	4.3	9.6 27.14
	1965	4.9	2.3	4.2	11.4 35.35
	1969	1.9	6.5	3.1	11.5 45.74
	1970	0.1	7.8	3.4	11.1 49.96
	1971			3.2	11.9 55.65
	1972	1.2		3.4	7.4 61.18
	1973	n.a.	-----		n.a.
U.S.:	1961	2.5	0.9	4.0	7.6 525.7
	1965	3.6	2.1	4.1	9.8 692.1
	1969	2.0	1.9	4.6	8.5 927.9
	1970	1.2	-0.6	6.2	6.9 983.2
	1971	1.7	-1.2	6.3	6.8 1059.7
	1972	2.2	-0.1	5.1	7.2 1161.9
	1973	2.2	0.6	6.2	9.1 1297.5

Source: OECD, National Accounts, 1961-1972; 1962-1973, Vol. 1.

^{1/} Savings excluding depreciation by OECD definitions.^{2/} In billions of local currency.

TABLE 3.--Aggregate Capital Structure of Nonfinancial Corporations
1965-74
(Billions of dollars)

Year	(1) Short-term debt	(2) Long-term debt	Equity	(1)/(2)	((1)+(2))/(3)
1965	172	176	404	.975	.864
1966	189	194	437	.978	.878
1967	198	215	471	.921	.879
1968	228	238	506	.956	.921
1969	259	261	551	.991	.944
1970	269	290	594	.927	.942
1971	278	321	645	.865	.932
1972	302	356	706	.847	.934
1973	349	394	765	.887	.971
1974	404	438	876	.922	.963

Source: Flow of Funds Section, Board of Governors of the Federal Reserve System, 1974.

TABLE 4.--Comparison of Studies of Capital Requirements
(Per cent)

	NYSE	Duesen- berry *	Fried- man	DRI	N.P.A.
GNP growth	8.6	8.7	10.1	8.5	10.1
Inflation rate	5.0	3.0	6.2	4.3	6.0
Real GNP growth	3.4	5.5	3.7	4.0	3.9
Unemployment rate	n.a.	5.0	5.5	5.0	5.5
Long-term interest rate	n.a.	7.5	n.a.	8.0	n.a.
<u>As per cent of GNP:</u>					
Gross pvt. dom. inv.	16.4	15.8	15.8	15.5	16.4
Nonresidential	12.1	11.6	11.5	11.4	12.3
Inventory	.4	.9	.8	.6	.6
Residential	3.9	3.3	3.5	3.5	3.5
Total savings	14.2	15.8	15.8	15.5	16.4
Business	10.5	10.2	10.8	10.7	11.7
Personal	3.9	4.7	4.9	4.6	4.9
Govt. Federal }	.2	1.3	.1	.4	.1
State		-.3			
Other ^{1/}	n.a.	-.1	.2	-.2	-.3
Investment gap	2.2 ^{2/}	0	0	0	0

*--Refers to 1980, the end of projection period.

^{1/} Statistical discrepancy less net foreign investment.

^{2/} Represents an average annual gap of over \$50 billion for the 12-year projection 1974-85.



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AMP Incorporated

RANDALL H. CARPENTER
Time, Inc.

RONALD J. GUERRA
Kaiser Industries Corporation

HARRY C. MCCREARY
McCreary Tire & Rubber Company

CHARLES E. MORRIS
Mobil Oil Corporation

OTTO C. POBANZ
Federated Department Stores, Inc.

MILTON H. PUGSLEY
Chrysler Corporation

DAVID M. WOODROW
3M Company

EUGENE J. ZEPP
General Motors Corporation
Associate Member-Advisors

HOWARD A. GREGORY
Des Moines Flying Service, Inc.

R. S. NORTHINGTON
Piedmont Aviation, Inc.

JOHN H. WINANT
President

Honorable Dale Milford

Chairman, Subcommittee on Aviation
and Transportation R. & D.

COMMITTEE ON SCIENCE AND TECHNOLOGY
House of Representatives
Washington, D.C. 20215

Dear Mr. Milford:

The National Business Aircraft Association (NBAA) greatly appreciates the invitation to express its views concerning the "Future of Aviation", and on behalf of its 1350 member corporations operating general aviation aircraft in the daily pursuit of their business objectives, NBAA submits the enclosed documents for the subcommittee members' use. We ask that they be made part of the official record of the Subcommittee's hearings. We have chosen to confine remarks to several specific subjects which warrant the attention of the subcommittee, with full confidence that many other subjects which directly concern NBAA have been adequately emphasized in statements by other industry representatives and will therefore receive your attention without further iteration. We hope we have not erred too greatly on the side of brevity. NBAA, therefore, stands ready with the full resources of NBAA's Directors, Staff and Committees to assist the Congress in further inquiry on any subject which the subcommittee or individual members may wish to examine in greater detail.

Sincerely,

John H. Winant
President

JHW/te
Enclosures



CONTENTS

<u>TOPICS</u>	<u>PAGE</u>
PREVIOUS STUDY OF RESEARCH AND DEVELOPMENT	1
RECOMMENDED R & D RESPONSIBILITIES	1
NASA'S EXPANDING ROLE IN CIVIL AVIATION RESEARCH AND DEVELOPMENT	2
NSAS'S RESEARCH AND DEVELOPMENT (R & D) BASE	2 & 3
NASA AND APPLIED RESEARCH	3
THE ROLE OF THE FAA IN CIVIL AVIATION ENGINEERING & DEVELOPMENT	3
EMPHASIS ON AIRPORT DEVELOPMENT	3
THE NATIONAL AIRPORT SYSTEM PLAN	4
NEED FOR TRAINED MANPOWER	4
TRAINING, SCHOOLS AND TECHNIQUES	4
THE PUBLIC SCHOOLS	4 & 5
IV - SAFETY NEEDS	5
THE NATIONAL TRANSPORTATION POLICY AND CONGRESSIONAL GUIDANCE	5 & 6
A THUMBNAIL SKETCH OF NBAA	7

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THE FUTURE OF AVIATION

NATIONAL CIVIL AVIATION RESEARCH AND DEVELOPMENT POLICY

PREVIOUS STUDY OF RESEARCH AND DEVELOPMENT

Over the past twenty years there have been many studies directed at identifying what should be done to assist the future development of aviation, who should undertake and be responsible for the various tasks, and how much funding should be allocated to insure that the results will foster the growth of aviation.

Several of the efforts are listed below:

- a) Civil Aviation Research and Development (CARD) - An assessment of federal government involvement - 6 Ad Hoc Committee Reports - 1968 - Aeronautics and Space Engineering Board, National Academy of Engineering.
- b) Department of Transportation - Air Traffic Control Advisory Committee - 1969.
- c) Department of Transportation - National Aeronautics and Space Administration - Civil Aviation Research and Development Study - 1971.
- d) President's Aviation Advisory Commission - The Long Range Needs of Aviation - 1973.

Although there are many and varied conclusions and recommendations that are presented in these reports, several were repeated enough so that they crystallize into what we consider a meaningful overview of how the civil aviation R & D Program should be handled in the future.

NBAA is concerned that there is fragmented control over the R & D support agencies and testing facilities assigned to NASA and the FAA. FAA works primarily with the Oklahoma City Center, National Aviation Facilities Experimentation Center, MITRE CORPORATION and the Transportation Systems Center. NASA has Wallops Island, Langley and Ames Research Centers and others. In the recent past NASA and FAA have become more closely allied and are presently participating in the following cooperative projects: Aviation Safety Reporting System, Terminal Configured Vehicle program and improved safety for general aviation aircraft.

We think that the cooperative programs should be expanded; however, there should be a detailed review of supporting agencies and a realignment and possible reduction of testing locations and/or facilities.

RECOMMENDED R & D RESPONSIBILITIES

The Department of Transportation should provide the leadership in conducting system studies to identify, analyze and rank civil aviation goals as well as the research and development needed to attain these goals.

The National Aeronautics and Space Administration should be responsible for research and development in all areas of importance to civil aeronautics.

The Federal Aviation Administration should, in addition to operating the airways network, be responsible for systems testing of resulting operational concepts and hardware.

The National Oceanic and Atmospheric Administration should be responsible for all R & D related to aviation weather.

NASA'S EXPANDING ROLE IN CIVIL AVIATION RESEARCH AND DEVELOPMENT

The NBAA has been privileged to be a participant in NASA's General Aviation Research and Technology Panel (RTAC) for the past two years and offers these comments based on that knowledge and exposure.

NASA's traditional capability and expertise has been increased by its successful efforts in space programs. It appears, however, that other government agencies, (e.g. FAA, EPA) have not fully utilized NASA's abilities to seek solutions, but rather have used NASA to examine a given problem for which the solution has often been predetermined. An example of this was the question "How can the pilot fly a two-segment approach for noise abatement?" The FAA and EPA did not ask NASA what were the best noise abatement flight paths or procedures but asked to evaluate a specific method for flying a predetermined flight path.

It should be a lesson to all that it was NASA expertise which developed and proved that relatively simple (and inexpensive) decelerating drag approaches were more effective than the potentially hazardous two-segment techniques. The potential savings in tax monies for ground-based electronic equipment amounted to millions of dollars.

The foregoing example conclusively indicates that NASA should be a full partner with other governmental agencies, particularly those with regulatory powers. NASA should be permitted unfettered opportunity in problem solving without being given predetermined avenues of solution.

The lack of a major contributory role for NASA in air traffic control is well documented. Only recently was NASA directed to assist in the evaluation of existing collision avoidance equipment (CAS). Three equipments had been developed and produced but since each utilized a different technique, the need to select the most suitable had created an impasse at FAA. This evaluation was ordered by the Congress in an attempt to provide a CAS, if necessary. At no time in the past was NASA ever requested by FAA to recommend a solution to the potential of mid-air collisions in spite of the fact that NASA had earlier done some work in this area including infra-red and doppler techniques.

The failure to utilize NASA is undoubtedly the reason why NASA has never played a role in designing the Nation's air traffic control system. The insistence of FAA policy makers in making all elements of the system dependent on ground control has led to increasing equipment demands on aircraft. FAA's insistence is open to reasonable doubt as to effectiveness, either in terms of cost or safety.

The Subcommittee should give serious thought to indicating that NASA the foremost research agency in the national aviation structure must be consulted more fully in developments affecting U.S. aviation.

NASA'S RESEARCH AND DEVELOPMENT (R & D) BASE

The heart of NASA's capabilities rests upon the continuance and expansion of its

basic research. In general aviation, in particular, this expertise is only recently beginning to include research on turbine-powered propulsion systems for smaller aircraft. Considering that national environmental constraints, without regard to aircraft size or use, are being felt by the aviation industry, such research is obligatory. NASA's unique capability and facilities make it the logical place for this important research to be done.

The value to the Nation's economy and balance of trade of the American aviation industry is well-documented elsewhere so NASA's potential contribution to it must be encouraged.

NASA AND APPLIED RESEARCH

The traditional dividing line between research and application has become less and less defined in recent years. The products of research are often not usable if some degree of "application" research is not also accomplished. Often application or "system" development is necessary to justify the expenditure of R & D funds. NASA has recently adopted a managerial concept embodying application 'themes' of which General Aviation has been designated as an essential theme.

This Theme concept should be encouraged and endorsed. It is NBAA's considered opinion that use of the theme for programming will result in cost effective results, together with more timely solution of priority problems. Typical technology areas under the General Aviation Theme are low-cost engine projects, stall-spin characteristics, etc.

THE ROLE OF THE FAA IN CIVIL AVIATION ENGINEERING AND DEVELOPMENT

We have some concerns regarding the FAA internal E & D complex. At the present time there is a Systems Research and Development Service which is responsible for some 21 E & D programs. When the major program of automation was being developed, a System Program Office was established to properly manage the project. Other than enhancement projects that program is basically completed; however, the large numbers of personnel that were added to the E & D complex are still in place and now FAA is looking for projects to keep the engineers busy. A Flight Service Station modernization group has been formed, notwithstanding the users' strong contention that the modernization program should be an "off-the-shelf" effort.

The Office of System Engineering Management was established to insure that all FAA E & D would have an inter-relationship and that all programs dovetailed into a sensible coordinated package. Although program plans were to be written for each of the 21 programs only a handful have been completed. Meanwhile the architect of this concept has left the agency.

EMPHASIS ON AIRPORT DEVELOPMENT

Research and development in recent decades has very frequently short-changed the airport half of the airport/airspace system. Category II approach facilities, for example, included research of centerline lighting for runways without properly investigating problems which recessed lighting aids suffer in snow accumulation.

Some thoughtful observers have also noted that extensive investment in research to reduce spacing between aircraft (e.g. wake turbulence avoidance systems) will yield less capacity improvement than the relatively cheaper expedient of additional parallel runways. Research and development in airport and airport-related facilities has been so lacking that it is nearly impossible to define where to begin; however, NBAA suggests that consideration be given to priority study of optimum land use development and airport configuration for various combinations of air carrier/general aviation mix.

THE NATIONAL AIRPORT SYSTEM PLAN

A keystone to the effective execution of research and development is the establishment of an effective and functional National Airport System Plan. The National Airport System Plan should be drawn by the Secretary of Transportation in a manner which will identify the airports which serve our national air transportation system, and serve as a requirements document against which the efficacy of R & D proposals can be gauged.

NEED FOR TRAINED MANPOWER

No other new development of this century has affected the life of the world's population more deeply than has aviation. Aviation has literally pulled the world together. Its "third dimension" has created not only new standards for geography, government and business but also technology. If we are to continue our leadership in aviation, then we must maintain a reservoir of trained manpower.

Many of today's achievements rose from the needs of World War II. As technology developed new and more complicated air-machines, so people were needed to take care of them. World War II produced a vast amount of talent that the civil aviation industry literally devoured. A manpower pool was thus made available that exceeded civil aviation's demands for many years, however we will be faced with a trained manpower crisis in the near future since the World War II trained manpower pool is slowly drying up as those people reach retirement age. For example, civil aviation could be short of trained aircraft mechanics within the next five years when the veteran mechanics who received their training in World War II are retired. It is estimated that 75,000 of World War II veteran mechanics will retire. Such people make up about one-third of the 200,000 maintenance work force, which includes the airlines and the military.

TRAINING, SCHOOLS AND TECHNIQUES

Recent reports indicate that the present training schools and programs are not preparing enough new mechanics to fill the void. Even if all aviation maintenance schools in the U.S. run at maximum enrollment, the new supply would not equal the attrition.

Electronic Technicians are also in short supply, and training is inadequate. The student pays between 8 and 10 thousand dollars for training (2 year college level) and the end result is a well educated engineer but not the desired technician.

Helicopter Mechanics are experiencing difficulties in obtaining the proper training. They are victims of training techniques that stress the fixed-wing airplane. The helicopter is popular with business and commercial operators and the demand for helicopter mechanics is increasing daily.

THE PUBLIC SCHOOLS

As the local area school budgets become victims of inflation, so also may go some of the elective curricula.

Back in World War II, "Preflight Aeronautics" was taught in an estimated 10,000 high schools in the United States. Following the war, the aeronautic courses disappeared from the schools and were made available through the Civil Air Patrol. Today it is estimated that fewer than 1,500 high schools in the U.S. provide a formal elective course, keyed to basic aviation subject matter.

Today the impact of aviation on contemporary society is a powerful and growing force that must be reckoned with. If aviation growth in the next decades comes as

forecast, then we do, indeed, have a major undertaking to cope with.

Aside from our awareness of the precedents for aviation education in the public school system there is a definite educational justification for aviation courses at the high school level. In a study of 400,000 teenage pupils by the U.S. Office of Education's Corporate Research Branch, aviation ranked as one of the top career choices by both boys and girls. By endorsement and accreditation, many educational councils and associations have endorsed aviation curriculum at the secondary level.

Since the public will ultimately derive the benefit from education, it would seem that the R & D funds for studies or program direction will be necessary to insure there is a "Future of Aviation" where trained manpower is concerned. Specifically, it is recommended that the projected need for the future training of the aviation work force needs to be examined to insure there will be the right type with the right training available. Secondly, that secondary schools be encouraged to include subjects exposing the students to the needs and values of aviation.

IV - SAFETY NEEDS

One of the requirements for a healthy growing aviation community is safety. Our government and aerospace industry has spent billions of dollars on research and development intended to enhance aviation safety. The blending of technology with judgment and safety has made the U.S. aerospace industry the safest on earth. In order to insure that we continue to lead the way, research and development must continue to play a vital role.

"Human Factors" is high on the list of much needed research. Controlled groups such as military pilots and perhaps airline pilots have done extensive research on pilot behavior. But what about the remaining 735,000 pilots? Aviation medicine has shown that the psychological makeup of a person has a lot to do with his/her ability to pilot an aircraft and to react properly to demanding situations. Shouldn't all people who are flying or who intend to pursue a flying career be tested and counseled on their psychological traits in relation to aviation?

In aircraft accident investigation, too often just minimal effort is directed to the human factors involved. This is because it requires highly trained individuals such as a psychologist, psychiatrist, or flight surgeon to do the analysis. Perhaps research in this area would provide our accident investigators with a means to determine more easily the human factors involved in the accident causal area.

Windshear and turbulence are significantly high on the list of causal areas of aircraft accident. The problem has been in locating and forecasting their locations and severity. The continued research of these weather phenomena is needed to insure our ability to predict and brief all pilots on their effects on flying.

The results of NASA's work in the crashworthiness field has been most commendable. It is highly recommended that they continue their research in this vital area of safety. It must be pointed out however, that there is some duplication of effort in this area between NASA and FAA. NBAA's recommendations, if followed, would result in NASA being charged with full responsibility for research in crashworthiness, as well as other areas.

THE NATIONAL TRANSPORTATION POLICY AND CONGRESSIONAL GUIDANCE

The National Business Aircraft Association is vitally interested in the future of aviation and is seriously concerned about the lack of national policies relating to

aviation. We are aware that there has been great difficulty in drafting a comprehensive national transportation policy, but we feel that this is a logical first step and that without it there is great difficulty in determining what R & D is necessary for the future of civil aviation.

Major budget decisions are being made daily in the marketplace by the entire aviation community. These decisions are being made without firm national policies on noise, pollution, land use, RNAV, OMEGA, LORAN, Satellites, navigational aids, ILS/MLS, state and county authority over airports.

Congress can provide the American public with a more comprehensive view of what the future of aviation will be in this country, assist in delineating responsibilities for specific facets of the industry and direct the publication of policies that will assist those that are in the business of purchasing and utilizing airplanes. Hopefully the program will provide sufficient overview and time-phased checks and balances to insure that it is proceeding as planned.



A Thumbnail Sketch of NBAA

The National Business Aircraft Association was incorporated February 7, 1947, under the laws of New York state. It is a not-for-profit corporation to:

- Promote the aviation-related interests of persons and corporations using aircraft for the conduct of business
- Foster among them the highest degree of operational safety and efficiency
- Promote and maintain an understanding at all governmental levels of business aviation's problems—but more importantly, its benefits—to society and the economy as a whole, with the goal of assuring a free flow of communications and mutual trust in the formulation of regulations affecting business aircraft
- To inform and educate the public and communications media about the role of business aircraft in a modern economy so they will better understand its function as a business tool for the ultimate benefit of all citizens

The NBAA represents approximately 1,200 businessmen and corporations which generate more than one-third the gross national product of the United States. The association has earned and enjoys a reputation for responsible and thoughtful presentation of its members' best interests. These members fly well over 2000 aircraft in the conduct of business, ranging from intercontinental business jets of airliner size to helicopters and single-engine light aircraft.

Through its professional staff of specialists—supported in Washington by an administrative staff—and through its membership-based national committees, NBAA carries out policies established by its elected board of directors.

Also at the national level, the staff interprets business aviation's accomplishments and requirements to federal regulators and policy-makers; analyzes governmental proposals and actions from its members point of view; generates public information programs; draws management, technical, operational and safety information from its members and publishes it for other members guidance and use; and arranges and conducts an annual meeting including seminars and other educational sessions which draw 4,000+ persons.

The NBAA staff coordinates and implements the work of the following membership committees: Airports, Air Space/Air Traffic Control, Corporate Aviation Management, International Operations, Support and Services, and Technical committee, which includes about 60 mem-

bers concerned with dozens of types of aircraft as well as a maintenance and engineering subcommittee and an avionics subcommittee.

NBAA's staff chief executive is John H. Winant, president, with association offices at 401 Pennsylvania Building; 13th St. and Pennsylvania Ave., N.W.; Washington, D.C. 20004. Telephone (202) 783-9000

Why Business Aircraft?

What makes the business aircraft worthwhile? This is usually the first question asked about aircraft in the role of a business tool. Many people feel airline services should be sufficient, but this is like asking a man why he owns an automobile instead of taking the bus to his destination.

In addition to those reasons which are uniquely valid to each business operation, below is a partial list of reasons why businesses own aircraft:

- Permit use of *all* of America's 12,700 airports, heliports and seaplane bases, because at the end of 1974 only 417 airports had certificated airline service in the 48 contiguous United States. Without such local air transportation provided by a business's own aircraft, many small communities might lose their resident industry to metropolitan complexes.
- Convert travel time from a management loss to usable business hours
- Provide a private enroute conference room
- Encourage establishment of branch offices in smaller communities
- Allow picking up or dropping off key people enroute to major conferences
- Conserve valuable executive time by providing flexibility of scheduling and destinations; executives plan travel around appointments, not vice-versa
- Convey public image of a modern, well-run company and the prestige which accompanies such an image
- Increase customer contacts by expanding a company's marketing area

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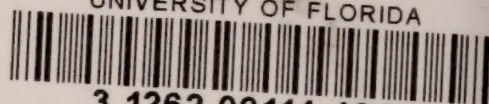
- Minimize "reaction time" to new business opportunities
- Help retain or acquire key personnel in competition with other progressive companies
- Operate as inter-plant shuttle or freight carrier
- Increase frequency of face-to-face communication between management and employees, and between management and customers
- Provide means of surveying new plant or branch locations of all kinds
- Permit bringing the customer to the product where the reverse is not possible
- Increase special services to customers, such as instant delivery of a critical part or provision of an engineer to check out a new machine in the customer's plant

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